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# PORTS OF THE PACIFIC.

BY

H. M. CHITTENDEN, M. Am. Soc. C. E.
ASSISTED BY A. O. POWELL, M. Am. Soc. C. E.

WITH DISCUSSION BY

MESSRS. L. J. LE CONTE, E. P. GOODRICH, LEWIS M. HAUPT, AND H. M. CHITTENDEN.

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# PORTS OF THE PACIFIC.*

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To describe any one of the larger ports of the Pacific Coast adequately would exceed the admissible limits of this paper. To describe them all with anything like minute detail is clearly impossible, and it is assumed that, in assigning this topic, the intention was that it be treated only on broad general lines which should give a comprehensive view of the subject as a whole, rather than a study in detail. Even with this understanding, the scope of the subject is so vast that its compression into the compass of a professional paper seems little better than the preparation of a table of contents. The attempt has been made, however, and its results are presented herewith under the following headings:

I.—Strategic Relations of Coast Ports.
II.—Descriptive Data.
III.—Engineering Problems.
IV.—Administrative Systems.
V.—Plans for the Future.
VI.—Influence of the Panama Canal.

The paper will treat only of those ports north of the boundary between Mexico and the United States.

*This paper was presented to the Annual Convention at Seattle, Wash., and also at the meeting of November 20th, 1912.

## I.—Strategic Relations of Coast Ports.

*Commerce of the Pacific.*—Since the days of Magellan, imaginative minds have pictured the Pacific Ocean as the future home of the world's commerce. There is something in the immensity of that ocean, in the present vastness of the population on one shore and the future vastness of that on the other, which conjures up visions of argosies such as the Mediterranean or the Atlantic has never known. The situation as it actually exists, however, makes this picture somewhat of an illusion. The very wideness of the intervening sea is a mighty barrier to economic intercourse across it. The breadth of the Pacific as compared with that of the Atlantic, depending on the latitude, is as two or three to one; and, while the cost of transit and loss of time may not be in the same proportion, there is still a wide disparity against the larger ocean. There are also the almost insuperable barriers of race and economic conditions on the Asiatic Coast. We do not admit the Oriental to our shores as we do the European. That immense source of traffic which has sustained its thousands of ships on the Atlantic is cut off on the Pacific. Likewise those Oriental countries have little to offer the traveler which can compare with the lure of European civilization, ancient and modern. Tourist traffic across the Pacific is a bagatelle compared to that over the Atlantic. Finally, the deep poverty of the hordes who swarm the Asiatic shores, and the backward condition of industry there, are not promotive of vigorous commercial intercourse, for they offer relatively little to sell and less with which to buy.

Thus it results that the commerce of this ocean, great though it be, is small compared with that of the Atlantic, and small to what might be expected from the millions of inhabitants affected by it. Its growth in the near future, strange as it may appear, is more dependent on the countries which border the Atlantic than on those washed by its own waters. As far as the Pacific Coast is concerned, the eyes of its people are turned east rather than west. It is there that their kindred dwell; it is there that the capital exists which shall develop their boundless resources; it is thence that must come those who shall help to populate their shores. It is this fact—that their future is on the Atlantic rather than on the Pacific—which makes the opening of the Panama Canal an event of such tremendous import to them. It is bringing them to their own. It fronts them toward

Europe. It opens to them the treasures of the Occident—far more potent, if less romantic, than those of the Orient. It gives them something of the advantage which the eastern shore of the Continent enjoys by reason of its closer relation to the fundamental sources of our civilization.

If this condition is true of the present, and will remain so, to a degree, for the indefinite future, let it not blind us to the profound changes which are taking place in those ancient, and, but yesterday, non-progressive, countries which lie on the other side of the Pacific. When we consider what a volume of commerce the accidents of political fortune have turned in this direction from the distant Philippines; when we reflect on the marvelous progress of modern Japan; and when we note the amazing changes now going on in that venerable nation which has slumbered indifferent to the rest of the world for thirty centuries or more, we cannot afford to take a pessimistic view of our future relations with that side of the globe. If ever these people accomplish what is within their practical reach; if ever they turn to account, as is done in Europe and America, their wealth of natural resources and their own capacity for industrial development, surely there will result a mighty increase in trade between them and the rest of the world, and of this the American Continent will enjoy the greater share.

Thus, while the Atlantic holds out to us the brighter present prospect, there is brilliant promise in the Pacific, and in every direction the future is big with hope. Visions of the coming day are profoundly stirring the minds of men. Expansion is in the air. The measureless force of unseen psychological influences rushes the world along whether it will or no. Doubtless, it builds exaggerated hopes and paves the way to much disappointment, but its very exuberance of faith is an earnest of vast accomplishment.

This far-reaching movement, which has been crystallized into definite form by the approaching consummation of the greatest engineering work of ages, finds its intensest expression along the Pacific Coast of North America. To other parts of the world, the Panama Canal means simply increased opportunities for trade; to the Pacific Coast it means a new lease of life through the elimination of those barriers which separate it from its true source of sustenance and growth. Everywhere along the Coast, faith in the beneficial results

of this great work is unbounded. It is a faith, moreover, which expresses itself in works. From Alaska to Lower California, the Coast is getting ready for the Canal. It is putting its house in order. It is spending in this work prodigious sums of money. The present decade will witness an expenditure in port development of probably $50 000 000. The slogan which has won this vast sum from the pockets of the taxpayers is: "Get ready for the opening of the Panama Canal," and the formal celebration of that event will find the work well toward completion.

It would be idle to pretend that this prodigious effort springs solely from an actual necessity of providing for the increase of traffic that will result from the opening of the Canal. The popular belief is, of course, that this is the case; but those who have studied the situation closely know better. They realize that the movement is being overdone, but they recognize that it is bound to keep on through the fear which each port entertains of what its sister ports may do. The stigma of possible failure in the race and fear of loss of prestige are the potent forces which are back of these extraordinary efforts. Los Angeles or Seattle would find it difficult on the cold basis of rational business foresight to justify their enormous prospective outlays; but they find ample justification in the necessity of keeping up with a procession which now stalks with tremendous strides from one end of the Coast to the other.

*Competition of Ports.*—This interesting state of things suggests a primary basis for comparing the ports of this Coast, namely, their relations to one another as commercial rivals. In the long stretch of coast line from Latitude 32° 30′ to Latitude 54° 40′, there are certain points of true strategic value; that is, points the possession of which gives the possessor important advantages over his competitor. Broadly speaking, there are two great divisions of the Coast from a commercial point of view—the north and south—with the Oregon-California line the approximate boundary between them. Only in a very general sense are these two sections of the coast competitors. They both reach out, it is true, to Hawaii, the Orient, and Alaska, and inland to common interior points; but each has some advantage peculiar to itself—a sort of proprietary right in certain spheres in which the other seems rather an interloper. The competition in such cases

is not keen, for the advantage of the more favored rival is too pronounced to be coped with successfully.

It is in a narrower sphere that the competition of these ports becomes really intense. San Francisco, Los Angeles, and San Diego have little to fear from the ports of the North, for their respective hinterlands merge only in the far interior of the Great Basin, but they have a wholesome respect for one another. Portland poaches but slightly on San Francisco's preserves, and Puget Sound still less, but the port on the Columbia never for an instant lets her sisters farther north forget her existence. Puget Sound and the ports of British Columbia are also competitors of a strenuous type in spite of the artificial barriers of nationality, tariff, and different customs and laws. In these local groups competition is really keen, and each competitor is feverishly anxious as to what its rivals are doing, while the still smaller units of the group flourish either by virtue of special advantages or simply on the crumbs which fall from their wealthier sisters' tables.

*San Francisco Bay.*—Having thus touched in most general terms on the trade relations of different sections of the Pacific Coast, let us consider in some detail the principal ports, still from the point of view of their commercial relations. Whatever changes the future may have in store, it is now true, and for a long while will so remain, that San Francisco Bay is far and away the most important port on the Coast. It is a wonderful port—wonderful in the strategic relation to its California hinterland and to the great interior of the country; wonderful in its physical conformation as a vast sheltered harbor opening in, through a narrow and easily defended entrance, from a coast line almost devoid of harbors for hundreds of miles in either direction; wonderful in its romantic history, and wonderful in its relation to the commerce of the world. Nature wrought a masterpiece when she made San Francisco Bay. Its great expanse and its navigable connections north and south, through the rich valleys of the San Joaquin and Sacramento, fit it perfectly as the entrepôt of a vast empire. The work of Nature was supplemented by the good offices of fortune, which early turned the attention of the world to this port and laid the foundation of its future greatness so deep that neither earthquake nor the growth of rivals can shake it. The Golden Gate—named three centuries before, in beautiful prophecy of

the Argonauts of Forty-nine, whose anchors dropped into yellow sands brought down by the slicken-laden streams of the Sierra—was the scene of a mighty commerce while yet only random traders sought the furry wealth of the harbors farther north. The first transcontinental railway had poured its traffic into the valley of the Sacramento for twenty years before any other portion of the Coast was similarly favored. San Francisco had written the most important chapter of her history while her sister ports were still almost unknown to the world. Congress did well when it selected the California metropolis as the site for the celebration of the opening of the great Canal. What a contrast it will be—the struggling mass of humanity and freight on its way across the fever-stricken Isthmus to the land of golden promise in Forty-nine, and the floating palaces which will then pass safely through Culebra Hill to a scene of resplendent riches undreamed of by even the wildest imagination of sixty-six years before! Where else on the round earth has modern progress wrought so great a change in so short a time?

*Los Angeles and San Diego.*—In Southern California, the location of highest strategic value, from a commercial point of view, unfortunately, happened to be where Nature did not provide a harbor, while the one really good natural harbor on that section of the Coast is not located where it will best serve the commercial needs of the country. Los Angeles, by virtue of its relation to the great Southern trade routes east, its marvelous resources in agriculture, its close proximity to the oil fields of Southern California, and the inestimable wealth of its winter climate (not exclusive in this, however), is incontestably the center of activity of Southern California. So little did Nature do in the way of providing a port in that vicinity, however, that the town did not grow up on the seashore at all, but twenty miles inland, and the possibility of making it a genuine seaport was clearly an afterthought in its development. Now, this consummation is its chief ambition, and a superb effort is being made to realize it. Los Angeles will become a great port, not because Nature made it so, but because her own virile people have said so. Its future harbor will be almost wholly artificial, but it will be a great harbor nevertheless, and will stand all the more to the credit of its people because of the sacrifices which they will have made to obtain it.

Southeasterly from Los Angeles, 89 miles, lies the splendid land-locked harbor of San Diego, ideal in its physical advantages. The fact that it never has become of first importance, however, shows that it requires something besides Nature's aid to make it a great port. It is not well located with reference to rail routes east; it has not as good a tributary country as Los Angeles; it is hemmed in by bold uplands close to the shore; and, worst of all, it suffers the purely artificial handicap of close proximity to the National frontier. Still, in spite of these drawbacks, the great natural advantages of the harbor, the lack of such advantages at Los Angeles, and the arbitrary rail tariffs which until recently have made freight from Port Los Angeles to the main city cost as much as from San Diego itself, though four times as distant, make San Diego a powerful competitor of her sister city to the north. Of course, she is bound to lose something of her relative advantage as Los Angeles develops her port, and particularly when the proposed municipal belt line connects that city with the sea and reduces freight rates to a nominal figure.

These two Southern ports have naturally cut somewhat into the trade of San Francisco, and will continue to do so. This is to be desired, as far as they may better serve the needs of the public as a whole, and beyond that point they are certain not to prevail if the communities of San Francisco Bay do their duty. California is a State of vast extent and immeasurable resources, and its hinterland is all the country to the eastward. In this illimitable field, and with the boundless ocean to the west, there will be sustenance for all, and the final balance among the ports will be adjusted on the basis of maximum efficiency of service to the public.

*The Columbia.*—Northward from San Francisco the first location of high strategic value is the Columbia River—the chief river of the Pacific Slope—which here breaks through the mountain barriers and opens a low-grade route to the interior of the country. It is the only point in United States territory where the great Coast-Sierra-Cascade Barrier is completely traversed by a water-grade route. The main valley extends directly back from the sea a distance of 75 miles, where its tributaries begin to spread out until they expand like an enormous fan, giving arterial highways to a water-shed of 250 000 sq. miles, with routes across the Continental Divide to the far-spreading country beyond. The main stream is susceptible of improvement for

navigation as far as into British territory, and its principal tributaries can be navigated for short distances; but the rapid fall of most of the streams, and the invariable accompaniment of rock rapids, make the liberal use of locks a necessity, and this presupposes heavy cost. In any event, it is certain that the river will be improved in the near future so that boats can ascend at all seasons as far as Central Washington, say, to Priest Rapids. This water route and the low-grade rail routes on either side, ramifying along the tributaries in all directions, give the Lower Columbia ideal communications with its hinterland, considering the exceedingly mountainous character of the country.

Plate X shows, to any trained eye, the immense advantage of the situation at the junction of the Columbia and Willamette Rivers. It is a great cross-roads. To this point vessels from the ocean, once over the bar, can safely ascend. Here, rail and river take up the route to the far interior. South is the rich Willamette Valley and Nature's land route to California. North is the Cowlitz Valley and the route to Puget Sound. The possibilities of the situation are enormous and such as will survive all competition. The chief drawback, as far as its commercial relations with the outside world are concerned, is its connection with the sea. The Columbia Bar, built up from the detritus of a vast and steep-sloped water-shed, was originally the most formidable and dangerous known to navigation, and the problem of opening and maintaining a safe and commodious channel across it is one of the most difficult in the whole range of river and harbor engineering. Only a moderate degree of success has been obtained so far, and that at heavy cost. Other plans have been suggested, such as cutting through the sand spit to an artificial harbor to be built south of the jetty, or through the isthmus on the north to the fine natural harbor of Willapa Bay; but they have never received serious attention, and the plan of deepening the bar by jetty construction will probably continue. With it must go, hand in hand, the project of deepening the river itself in its 100-mile channel from the bar to the port. The situation is something like that at Los Angeles in that Man must be relied on to make good the large deficiency of Nature. This, as the writer has elsewhere observed, the enterprising citizenship of Portland is resolved shall be done, cost what it may, to the end that there may be realized, even more than at

PLATE X.
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OUTLINE MAP
SHOWING
COMMERCIAL RELATIONS
OF
PACIFIC COAST PORTS

present, the prophecy of one of her own poets, who has pictured the time:

"When through this Gate the treasures of the North
Flow outward to the sea."

*Puget Sound.*—Proceeding northward, the next great strategic point in the commerce of the Pacific Coast, and, in some respects, the most important of all, is Puget Sound. It is a vast inlet from the sea through a strait 15 miles wide and nearly 100 miles long, branching both north and south, in sheltered inland waters which abound in ideal natural harbors. So perfect are these harbors that their chief defect is an excess of what anywhere else would be considered almost the chief advantage, the depth in some being such that anchorage ground is scarce, and extending so close in shore as to make wharf building difficult and expensive. The tidal range is also large, with strong tidal currents, and the teredo is very active. Except for these drawbacks, the Sound harbors are ideal. Take Seattle, for instance. Into the spacious enclosure of Elliott Bay, a ship can enter without tug or pilot and pass directly to berth under her own steam in all conditions of tide, and in almost all conditions of weather, and always feel certain that her hull will not touch bottom. It is the most favored port in the world in this respect, excepting only one or two of its sister ports on the Sound, which enjoy the same advantage.

Nature has certainly lavished her richest favors on these ports and provided them with advantages which no expenditure of money can ever give to a port situated as is Portland or Los Angeles. But, as an offset to this great advantage, she has placed a handicap which is of very serious consequence; she has barred off Puget Sound from its great hinterland to the east by a massive mountain range, the lowest passes of which are more than 3 000 ft. high. These passes have been scaled successfully, it is true, and the terminal rail rates are the same as to Portland, but the handicap is there, nevertheless, and is the most serious commercial problem which Puget Sound faces to-day. It is as if the Catskill Range, with twice its actual height, extended along the coast in an unbroken wall from Boston to Baltimore, shutting out New York from its rightful hinterland. Local enthusiasts in both Portland and Seattle speak of their respective cities as the "New York of the Pacific." In truth, each is only half

New York; or rather, New York, in its natural advantages as a port, is the Seattle and Portland combined of the Atlantic. Its harbor rivals that of Seattle, while its Hudson River route to the interior rivals that of the Columbia. Puget Sound does not fully appreciate this difference. Seattle and Tacoma are spending millions in developing harbors which are already perfect beyond any in the world, but not a cent to overcome this barrier which stands between them and their hinterland. The writer once had the temerity to suggest that a low tunnel, serving all the railroads and giving practically a water-grade connection between the Sound and the Columbia Valley, was essential to the commercial supremacy of Puget Sound ports. Time alone will justify or discredit this prediction, but it is certain that with an outlay no greater than what has been expended on three of the Alpine tunnels, a line could be secured which would serve, on the most favored gradients and with shortest distances, the entire country from the Great Basin to the interior of Canada. Puget Sound is the natural entrepôt for the trade of Alaska, is a day nearer the ports of Japan and Northern China than San Francisco, and has the best harbors in the world. Only the natural barrier which separates it from its hinterland keeps it from playing the part which it should in the commerce of the Pacific.

We have considered Puget Sound as a great harbor whose entrance is the broad, deep Strait of Juan de Fuca. Inside the Strait there are numerous competing ports, of which Seattle is the central and most important. Thirty miles farther south is Tacoma, Seattle's most formidable competitor in United States waters. It has a harbor rivaling that of Seattle, and has been particularly favored by the great railway systems, which have given it an importance even beyond what its comparative advantages justify. Besides Tacoma there are the harbors of Everett, Anacortes, and Bellingham, all of which have splendid natural advantages and do a thriving trade. On the west side of the Sound is Port Townsend, once looked on as the coming port of Puget Sound, but now important mainly as the headquarters of the Customs District of the Sound and the Quarantine Station. It is on the wrong side ever to assume first importance.

All the great strategic points in United States territory, which we have considered, have been guarded by elaborate sea-coast defenses, while San Francisco and Puget Sound have been made great naval bases.

*Vancouver, B. C.*—Seattle's greatest rival for commercial supremacy north of Portland and Tacoma is Vancouver, B. C., a rival whose strength lies not so much in its natural advantages as in the artificial conditions arising from its being in a different national jurisdiction. It has a good strategic location, it is true, being at the outlet of the second greatest river of the Pacific Coast; but its harbor is inferior to those farther south, and its rail connections east, even to Central Canada, are inferior. Its early growth was due primarily to the fact that it was a Canadian port. That the port would have developed where, or as rapidly as, it has, if there had been no international boundary near by, may well be doubted. As conditions actually exist, however, taken with the present status of American navigation laws by which cheaper foreign shipping is excluded from our coastwise trade, Vancouver is a formidable competitor with ports farther south. In the fish and lumber export trade, particularly, conditions tell heavily in her favor.

*Prince Rupert.*—Prince Rupert is the northernmost Pacific terminus of the transcontinental lines, and will remain so until some line shall cross into the valley of the Yukon and descend that mighty river on its way to the westernmost apex of the Continent. It is 40 miles south of the international boundary of Alaska (54° 40′) and about 700 miles along the coast from Seattle and that much nearer Alaska. It is the westernmost, as well as the northernmost, transcontinental terminus, and is 500 miles (according to the statement of the Grand Trunk Pacific officials) nearer Asia than any other terminus on the Pacific. It is said that a traveler from China would be able to reach Winnipeg, *via* Prince Rupert, before he could reach Vancouver, if he were to go by that port. Add to this the fact that the gradient over the mountains, with the exception of about 20 miles of 1% on the west slope, is everywhere under five-tenths, and most of the way much less than this, and some of the physical advantages of the route are apparent. Add again the proximity of Prince Rupert to the limitless wheat fields of Canada, the fact that it is in the very center of the salmon and whale industry, among inestimable quantities of virgin timber, and its great future seems doubly assured.

Its advantages are offset to some extent by the severity of northern winters, but chiefly by the different nationality of the territory (Alaska) which it is best fitted to serve.

*Secondary Ports.*—Somewhat outside the rivalries of the great ports along the Coast, and flourishing on advantages which are peculiar to themselves, are several smaller ports. Among them, and the more prominent, are San Luis Obispo, about half way between San Francisco and Los Angeles; Humboldt Bay, on the North California Coast; Coos Bay, 200 miles south of the Columbia and serving an important section of Western Oregon; Astoria, just inside the Columbia Bar and the first port to be established on the North Pacific Coast; Grays Harbor, a great lumber port on the west coast of Washington, 45 miles north of the Columbia; and Victoria, an important harbor and naval base on Vancouver Island. There are numerous harbors on the Alaskan coast, but they are still in a state of Nature, as very little has been done toward converting them into up-to-date ports. The prospective opening of the coal fields of Alaska, and a more definite Alaskan policy on the part of the Government, will undoubtedly lead to the establishment of permanent facilities at some of these points in the near future.

## II.—Descriptive Data.

In its physical characteristics the Pacific Coast line of North America increases in severity from south to north, but there is less diversity in climatic conditions than one might expect, for such great differences in latitude, owing to the moderating effect of the ocean currents. It is not until well up on the Alaskan Coast that one finds the harbors regularly sealed by ice in the winter season. Storms are more severe in the northern latitudes, but this is more than offset, as far as coastwise trade is concerned, by the sheltered inland passages which extend for at least 1 000 miles from Southern Puget Sound north. The tidal fluctuation increases from south to north from a mean of about 4 ft. at San Diego to 14 ft. at Prince Rupert. The teredo is very destructive in all the waters of the Coast, but the limnoria is active only in Californian waters. Nearly all the tributary streams are heavy silt carriers, and the primeval bays and inlets are partly or wholly filled up, making dredging a necessary adjunct of harbor development all along the Coast, and necessitating costly training dikes to scour channels across bars or shoals. In Southern California, the immediate shores were originally lightly timbered; but from Northern California north they were covered with magnificent forests. The coast line is re-

markably uniform, and unbroken by indentations as far as the Strait of Juan de Fuca, but from there north the exact opposite is the case.

With these few observations on the broad physical characteristics of the Coast, more detailed consideration will be given to the several ports.

*San Francisco Bay.*—The Bay of San Francisco (including, in that term, San Pablo and Suisun Bays) has a total area of 420 sq. miles and a shore line of about 350 miles. The area exceeding 30 ft. in depth at low water is about 190 sq. miles. The extreme tidal range is 8 ft., and the mean is 4.3 ft. The tidal currents are strong in the Golden Gate and Carquinez Straits, amounting to 7 miles per hour at spring tides. The entrance to the Bay is about 1 mile wide and very deep, and is guarded by formidable defenses. In a half circle about the entrance on the ocean side, and some 6 miles distant, is a narrow bar with a ruling depth of 30 ft. at low tide and two crossings of over 40 ft.

The heavily silt-laden streams—the Sacramento and San Joaquin, with a water-shed of more than 60 000 sq. miles, extending 400 miles along the western slope of the Sierra—have brought down immense deposits into the Bay and are progressively reducing its area. It once extended far up the valley of each stream, but is now practically limited to the area below the Straits of Carquinez, for Suisun Bay is shoaled up so as to be of little use for navigation except on the through channel to the rivers above. The deposits have also invaded the Lower Bay and have shoaled the depth, over two-thirds of its area, to less than 18 ft. Due probably to the action of the inflowing tides, this shoaling has been forced mainly on to the east side of San Francisco Bay and the north side of San Pablo Bay, leaving the east shore, where Oakland, Berkeley, and Alameda now stand, quite unapproachable in their natural condition by any craft larger than a rowboat, while the shore of the San Francisco Peninsula has practicable depths for the largest shipping close in to the bank. It was mainly this condition that made the Port of San Francisco Bay develop where it did instead of on the east shore. Now that reclamation work is utilizing the shoal areas to make new lands by dredging out deep slips, shipping will gravitate more and more to the east shore in order to avoid ferry inconvenience.

The shoaling of San Francisco Bay is one of those great natural blessings which the unthinking are so accustomed to look on as a curse. One-tenth of its natural area, with deep connecting channels,

would serve every possible need of commerce, while the other nine-tenths would be of immeasurably greater benefit reclaimed and turned to industrial or agricultural use. Every cubic yard of earth washed down from the rugged slopes of the mountains is worth a thousand times more in those low areas, where it is turned to efficient use in the service of Man.

San Francisco Bay is perfectly sheltered from ocean storms, is not subject to flood effects except in the extreme upper portions, at the outlet of the Sacramento and San Joaquin Rivers, and is absolutely free from ice. There were originally several dangerous rocks in the channels, but these, for the most part, have been removed, the most important removal being that of Blossom Rock. In practically all respects the natural advantages of San Francisco Bay are of the highest order, and, if its human custodians are faithful to their trust, it is destined to remain for a long time the leading port on the Pacific Coast.

San Francisco proper and its port grew up on the narrow peninsula lying between the southern half of the Bay and the ocean, south of Golden Gate. As far as land communication to the north and east is concerned, the city is practically an island, and has to rely exclusively on ferry service. The water-front development extends from the northeast extremity of the peninsula around into the Bay, and as far south as the city and county boundary. The jurisdiction of the Board of Harbor Commissioners stops short at this point, which fact is clearly indicated on Plate X. At present the berthing space for all classes of vessels aggregates more than 10.5 miles. The several ferries to the east shore and other points land near the foot of Market Street, and carry 125 000 passengers daily. Exclusive of fairways or forbidden anchorage, there is, approximately, 100 sq. miles of available anchorage ground in the Bay.

Dock construction consists of three classes: Entire wooden construction, concrete subconstruction only, and complete concrete construction. Much trouble has been experienced with subaqueous concrete work, probably due to defective methods or inspection. Nearly all the sheds are built of wood, and their areas vary from 60 000 to 84 500 sq. ft. The State owns no dry docks, but there are two privately owned graving docks at Hunter's Point and two floating docks at the Union Iron Works Plant, besides the Naval Dock at Mare Island.

San Francisco is the only port on the Coast at which any great

amount of permanent sea-wall construction has been done. Work of this character has been carried on for the past twenty years. In that time, including work now in progress, nearly 13 000 lin. ft. have been built, at costs ranging from a little less than $100 to about $270 per lin. ft. The construction of the sea wall has resulted in reclaiming more than 25 acres, from which the annual rental now amounts to about $1 000 000, or considerably more than half the total revenue of the port.

The port's funds are derived from its regular revenues (rents, wharfage, dockage, tolls, etc.) and the sale of bonds. The regular revenues, from the beginning of the Board's operations in 1863, amount in round numbers to $28 500 000, and the funds from other sources, mainly bond sales, including recent issues still unexpended, to about $12 000 000. The expenditures for construction and repair amount approximately to $22 000 000, exclusive of the recent $10 000 000 bond issue. The running expenses of the port (salaries, law fees, etc.) amount to an average of 21.4% of all the disbursements. The total Federal appropriations for removing obstructions from the harbor amount to $516 000, so that the total outlay on the harbor, including recent bond issues, will be about $32 500 000. This, of course, is not all represented in actual present results, for much of it was for early work which has since been replaced, existing work probably not representing a present cost exceeding $10 000 000.

It is important to note that approximately one-half (of late years more than one-half) the revenue comes from ground rents, without which much larger bond issues would have been required.

The commerce of the port is very extensive. During the fiscal year 1908-09, 39 251 vessels of all descriptions were docked at the State wharves, and the short tons of freight passing over the wharves in the same period was 6 325 000. The Annual Report of the Engineer Department of the United States Army for the calendar year 1910 gives a total short-tonnage of 7 325 000, valued at $222 500 000, distributed as shown in Table 1.

The trade of San Francisco embraces every class of commerce that passes over the Pacific Ocean. The Government Transport Service on that ocean largely centers there, and the chief naval base of the Pacific Coast is at Mare Island in San Pablo Bay. In many other respects San Francisco stands far in the lead of any other port on the Coast.

TABLE 1.—Freight Traffic.

| Articles. | Amount, in short tons. | Valuation. |
|---|---|---|
| Flour | 98 089 | $6 670 052 |
| Corn | 6 320 | 221 200 |
| Wheat | 143 104 | 5 724 160 |
| Barley | 543 407 | 16 302 210 |
| Oats | 29 869 | 896 070 |
| Beans | 46 913 | 3 753 040 |
| Hay | 214 734 | 4 079 946 |
| Onions | 16 815 | 1 325 200 |
| Bran | 16 865 | 573 410 |
| Potatoes | 98 415 | 3 936 600 |
| Lumber | 1 599 275 | 20 790 575 |
| Shingles | 34 037 | 1 157 258 |
| Brick, cement, lime, etc | 62 814 | 1 307 038 |
| Coal, coke, etc | 623 174 | 7 276 328 |
| Crude oil | 2 786 980 | 13 934 900 |
| Paper | 22 107 | 2 210 700 |
| Wines, liquors, etc | 101 269 | 20 253 800 |
| Fertilizer | 25 170 | 830 610 |
| Salmon, codfish, etc | 89 180 | 15 723 656 |
| Butter, eggs, cheese, etc | 26 984 | 11 436 440 |
| Fruits, dried fruits, etc | 86 553 | 10 470 950 |
| Sugar, tea, coffee, canned goods | 295 089 | 38 342 350 |
| Silk, cotton, dry goods, leather | 31 159 | 13 370 800 |
| Wool, gunnies, matting, jute, etc | 29 182 | 5 836 400 |
| Rice, salt, coal oil, etc | 33 709 | 1 849 205 |
| Railroad ties, pig iron, etc | 116 302 | 1 528 762 |
| Miscellaneous | 147 062 | 12 676 488 |
| Total | 7 324 577 | $222 478 148 |

*Oakland and Alameda.*—The physical characteristics of San Francisco Bay, of which Oakland and Alameda occupy the east shore, have already been described. The distinctive east shore harbor is the San Antonio Estuary, which lies between Oakland and Alameda and extends entirely around the land side of the island on which Alameda is situated. It is referred to in Government reports as Oakland's inner harbor. A channel leads in, from deep water in the Bay, between jetties 800 ft. apart, which also serve as moles with ferry slips at the ends. The channel, as developed under the Government project now in force, will be 500 ft. wide and 30 ft. deep to a large "tidal basin" about opposite the center of Alameda, with a channel 300 ft. wide and 25 ft. deep entirely around the basin, and a depth of 18 ft. in the "tidal canal" connecting the basin with San Leandro Bay, an inlet of San Francisco Bay on the southeast end of Alameda Island. This magnificent inner harbor has a shore line on each side of about 7 miles. On the Oakland side there is approximately 10 000 ft. of berthing space for deep-sea vessels and 16 000 ft. for smaller craft. The harbor is a great industrial center, some of the largest plants on the Bay being located there. There are four dry docks.

From the point of junction of the Estuary with the Bay, the shore line to the north is occupied by transcontinental railroad terminals and shops of ferry lines. In this stretch of about 2½ miles frontage is the so-called western water-front on which the Municipal Government is making improvements.

The port's revenues come from tax levies, bond sales, rentals, fees, etc. The City Government has recently issued $2 500 000 in bonds, and contemplates duplicating this issue in the near future.

The commerce of the port is large and varied, amounting, in 1910, to 3 575 000 short tons, valued at about $140 000 000, of which approximately one-half was carried in merchant vessels and one-half in ferries.

All along the east shore, and at many other points on both shores of the Bay and of San Pablo and Suisun Bays, there are wharves and industrial establishments of one kind or another, of which only mention can be made here.

*Los Angeles.*—As already observed, Los Angeles was less favored by Nature as a port than any other important locality on the Coast, and the making of a great port there is the work of its enlightened citizenship. The harbor was an open bay protected only from westerly and northerly winds. It lay wide open to an exposure of 120° toward the south except for the meager influence of Catalina Island, 18 miles in the offing. From this bay, through a long crescent-shaped bar, formerly called Rattlesnake Island, now Terminal Island, there opened inland, by a channel only 3 ft. deep at low tide, what has come to be under development the inner harbor of Los Angeles. It is really the delta of Los Angeles and San Gabriel Rivers (erratic streams characteristic of the water-courses of that section of the country) which bring down heavy loads of silt in their periods of sudden floods. The outer harbor, being exposed to storms from the southwest, required artificial protection, and this has been provided by one of the largest breakwaters in the United States, extending from Point Fermin, previously referred to, easterly, a distance of 11 000 ft., to a low-tide depth of 48 ft. The space thus enclosed, measured back from a line drawn from the end of the breakwater perpendicularly to the shore, is 960 acres, and of this more than 400 acres has a depth of over 30 ft. The anchorage is good, the kelp which formerly was a great annoyance has died out, and the harbor thus formed serves its purpose excellently well. The mean tidal range is 4.1 ft., and the extreme 10 ft.

Great reliance for port facilities, however, is being placed on the inner harbor, which is almost wholly an artificial creation. Its entrance from the outer harbor is completely sheltered by the breakwater. Beginning with 700 ft., it widens to 1 000 ft. at a point 3 000 ft. in, and then rapidly narrows to 500 ft., which width it retains to a point 7 500 ft. in from the outer end. The width then increases somewhat, and the channel terminates at a distance of 12 000 ft. from the entrance in a turning basin 1 600 ft. in diameter. From the turning basin channels lead off to the main interior docks known as the East and West Basins, respectively, which, with their future ramifications, will become the center of Los Angeles Harbor. The situation can be better grasped by reference to Plate X. The present width and depth are 400 ft. and 20 ft. to "the foot of the wharves"; thence 25.5 ft. to the turning basin. The existing Government project contemplates a depth of 30 ft. up to and including the turning basin, and two channels, 200 ft. wide and 20 ft. deep, from the turning basin to the East and West Basins.

As already stated, the harbor is almost wholly of artificial creation, and it is costing vast sums, entirely apart from docks and wharves, to arrive at a point which Nature unaided has given to most of the other ports on the Coast. Los Angeles, though liberally aided by the Federal Government, is helping herself effectively. It is a fine example of a virile civic spirit refusing to be balked by Nature in the matter of access to the sea. It will eventually rank with such ports as Hamburg and Glasgow in the extent to which Man by his energy and persistence has overcome the deficiencies of Nature.

The total development of berthing space is about 19 000 ft., most of which is directly controlled by the railroads. There is no dry dock. The wharves are principally of timber construction, but in recent years there has been a tendency to extend the use of concrete and steel, and the recent controversy between the Board of Public Works and the Board of Harbor Commissioners turned largely on the choice between concrete and creosote piling for the substructures. There is no seawall construction, unless the great breakwater be classed as such.

The local funds for port development, so far, have come entirely from bond issues, but ground rent will doubtless become a source of revenue in the near future, together with the revenues from docks which the port authorities are planning to build. Local expenditure to

date, including that of the Village of Wilmington prior to annexation to Los Angeles, and including also outstanding contracts, amounts to $625 000. The City has voted $3 000 000 in bonds, and it gave a pledge to the Cities of Wilmington and San Pedro prior to annexation that it would expend not less than $10 000 000 in port development. The expenditure by the United States on the outer and inner harbors, including outside authorizations, is:

| | |
|---|---|
| Outer harbor | $3 078 000 |
| Inner harbor | 2 308 000 |
| Total | $5 386 000 |

A great saving fact in the enormous labor of building the Harbor of Los Angeles is its close relation to the industrial development of the city. The lands into which the waterways are being dredged are admirably adapted for factory locations, and the material of excavation is being used in making the necessary fills. The whole development goes hand in hand in a way to produce the best results.

The trade of Los Angeles is active and is steadily increasing. The principal articles of commerce are oil, cement, and lumber products. The estimated short-tonnage and valuation for the calendar year 1910 are given in Table 2, the totals being 1 709 000 tons valued at $47 000 000.

As yet no public terminal or belt-railway system has been constructed in Los Angeles, but the city is taking steps to acquire one which will serve the port and connect it with the city.

*San Diego.*—Nature has provided for San Diego, in the first instance, what Los Angeles with the expenditure of many millions can scarcely expect ever to equal. In general exterior outline the two ports are quite similar. Coronado Beach corresponds to Terminal (old Rattlesnake) Island, Point Loma to Point Fermin, while the entrances to the inner harbors are similarly situated in both cases. The difference is that at San Diego the entrance had a very good depth and ample shelter to begin with, while the inner harbor was already dredged. At Los Angeles there was a depth of 3 ft. at the entrance and no harbor to speak of. If San Diego had been as favorably located with respect to its hinterland as Los Angeles, the natural advantages of her harbor would have been decisive, always provided a virile and wide-awake people were charged with its development.

TABLE 2.—Freight Traffic.

| Articles. | Amount (customary units). | Amount, in short tons. | Estimated valuation. |
|---|---|---|---|
| Lumber | 579 842 876 ft. b.m. | 1 014 724 | $12 756 543 |
| Shingles | 243 595 000 pieces | 48 719 | 487 190 |
| Shakes | 4 204 000 pieces | 2 803 | 60 958 |
| Lath | 70 460 000 pieces | 19 572 | 147 966 |
| Ties | 696 308 pieces | 44 563 | 445 640 |
| Piles | 18 317 pieces | 17 584 | 366 340 |
| Poles | 43 526 pieces | 36 561 | 652 890 |
| Posts | 79 565 pieces | 2 387 | 59 673 |
| Logs | 7 940 pieces | 5 558 | 55 580 |
| Doors | 10 578 | 529 | 21 156 |
| Staves | | 525 | 15 750 |
| Lumber trucks | 182 | 75 | 4 550 |
| Grain | | 30 700 | 921 000 |
| Flour | | 3 523 | 176 150 |
| Sugar | | 2 028 | 202 800 |
| Paper | | 4 600 | 391 000 |
| Asphalt | | 9 587 | 67 109 |
| Coal and coke | | 6 976 | 71 390 |
| Cement | 225 350 bbl. | 45 070 | 450 070 |
| Pig iron | | 3 454 | 51 810 |
| Oils | 1 301 302 bbl. | 259 467 | 2 138 571 |
| Wool | 311 bales | 77 | 23 100 |
| Plaster | 79 600 bags | 3 748 | 37 480 |
| Salt | 741 bags | 78 | 2 028 |
| Rice | 6 170 bags | 308 | 20 533 |
| Brick | 377 000 pieces | 942 | 3 328 |
| Chemicals, drugs, etc | | 488 | 97 600 |
| Manufactured iron and steel | | 5 964 | 1 192 800 |
| Fruits and nuts | | 1 399 | 279 800 |
| Canned goods | 9 560 cases | 239 | 26 680 |
| Fertilizers | | 5 010 | 143 886 |
| Hay and feed | | 159 | 2 385 |
| Scrap metals | | 1 702 | 34 040 |
| Wines and liquors | | 424 | 84 800 |
| Live stock | 11 211 head | 3 080 | 213 792 |
| General merchandise | | 126 671 | 25 334 200 |
| Total | | 1 709 294 | $47 040 588 |

The area of San Diego Bay inside the entrance is 24 sq. miles, of which 1 600 acres is more than 30 ft. deep; and the length of shore line is 38 miles. The original depth of 21 ft. in the entrance has been increased by the Government to 30 ft., and the present project contemplates an enlarged channel of this depth 600 ft. wide. The present berthing space amounts to 4 500 lin. ft., with a low-water depth of 22 ft. All the piers are private property, but they are subject to sequestration by the City at any time on payment of actual value. There is no dry dock and no public terminal railway. There is a marine railway for vessels up to 1 000 tons burden. The Government maintains a torpedo and submarine boat station in the harbor, together with quarantine and coaling stations. There is an important ferry service between the city and Coronado Beach.

The present sources of revenue to the port are bond sales, of which only one (for $1 000 000, voted November, 1911) has ever been au-

thorized. The total Government appropriation for the improvement of the harbor is $810 000.

The commercial business of the port is shown in Table 3, which embraces the calendar year, 1910. The totals are 400 000 tons, valued at $22 500 000.

TABLE 3.—Freight Traffic.

| Articles. | Amount (customary units). | Amount, in short tons. | Estimated valuation. |
|---|---|---|---|
| Lumber | 80 066 000 ft. b. m. | 140 115 | $1 761 452 |
| Crude oil | 466 888 bbl. | 88 419 | 350 166 |
| Cement | 15 234 bbl. | 3 047 | 30 468 |
| Wool | 34 000 lb. | 17 | 6 800 |
| Salt | ..... | 392 | 10 192 |
| Ores | ..... | 2 714 | 542 800 |
| Manufactured iron and steel | ..... | 1 811 | 362 200 |
| Brick | 618 160 pieces | 1 545 | 4 950 |
| Grain | ..... | 445 | 13 350 |
| Fertilizer | ..... | 1 634 | 42 484 |
| Coal and coke | ..... | 38 954 | 154 057 |
| Live stock | 11 043 head | 3 036 | 147 984 |
| Pig iron | ..... | 2 961 | 44 085 |
| Onyx | ..... | 16 510 | 119 430 |
| Sulphate of potash | ..... | 1 774 | 66 269 |
| General merchandise | ..... | 94 674 | 18 934 800 |
| Total | ..... | 398 048 | $22 591 487 |

*Secondary Harbors South of the Columbia River.*—Between Los Angeles and San Francisco is the important secondary harbor of San Luis Obispo; and between San Francisco and the mouth of the Columbia are the important secondary harbors of Humboldt Bay, California, and Coos Bay, Ore. These harbors, roughly speaking, divide by equal intervals the long stretch of coast line between the principal ports. At San Luis Obispo the development work by the Government is in the nature of a breakwater to afford shelter; in the two northern harbors, it consists of jetty construction designed to deepen the natural channels over the bars. In all three ports the outlay has been heavy in proportion to the commerce. Some of the most successful jetty work on the Coast is at Humboldt and Coos Bays, but it is impossible. in this paper, to make more than a passing reference to it.

*The Port of Portland.*—This is the only port of those considered in this paper which, in its physical characteristics, is strictly a river port. It is so far inland that tidal fluctuation, though perceptible at periods of low water, is negligible. On the other hand, it is subject to all the fluctuations of level characteristic of rivers above tidal influence, and the range between extreme high and extreme low water

is more than 30 ft. The harbor proper is not on the Columbia, but on the Willamette, about ten miles above its mouth, though, in general terms, looking to the future, the whole of both streams, from Vancouver, Wash., to Portland, may be regarded as the port of the Columbia Valley. Being a river harbor, the whole trend of its development shapes itself to that fact, and its counterpart is to be found in such a port as New Orleans rather than in those which have been considered in this paper. Quay development, parallel to the current, is the rule, instead of slips or piers projecting into the stream. While diurnal fluctuations are absent, and no provision therefor is necessary in dock construction, the great seasonal fluctuations introduce even more serious difficulties in providing for differences of level.

The length of available berthing space for deep-sea shipping is about 6 600 ft. on the east side and 8 500 ft. on the west side. The corresponding figures for river boats and the mosquito fleet are 4 725 and 6 040 ft., respectively. Railroads own 25 800 ft. of water-front on the west side and 17 150 ft. on the east side. The port has two floating dry docks, but there is no municipal or belt railway.

As is often the case with a port situated far inland on a river, the problem of providing an adequate channel to the sea is the most troublesome. With 110 miles of river channel in which a low-water depth of 10 ft. was all that could be depended on originally, and with a wild and tempestuous bar at the river mouth over which the natural depth was only 20 ft., the problem of securing and maintaining a channel was the all-important one. The work on the bar must take rank among the greatest, if not the greatest, of the kind ever constructed. It has all been done by the Government. The channel improvement from the bar to Portland has been done jointly by the Government and the port in proportions of expenditure as shown on the following page. There is at present a depth of 26 ft. at low water, and the Government is about to commence work to increase this to 30 ft. The Government now has three dredges available for the work, and the Port of Portland has two, and it is expected that this fleet will be soon increased by two more.

The port's revenues come from tax levies, bond sales, dry-dock charges, dredging, and a few minor sources. Nothing is derived from dockage, wharfage, and similar charges. The total amount of funds provided by the Government and locally is approximately as follows:

| | | |
|---|---|---|
| By the Government—The Columbia Bar..... | $10 145 000 | |
| " " " River Channel to Portland ..... | 2 725 000 | $12 870 000 |
| By the Port of Portland, approximately..... | | 3 700 000 |
| By the Portland Dock Commission (bonds voted, but not yet expended) ..... | | 2 500 000 |
| Total ..... | | $19 070 000 |

As already stated, Portland is admirably situated on the land side to develop a large port business, but the channel difficulties between the port and the sea somewhat offset this advantage. The commerce, nevertheless, is large and varied, as will be seen from Table 4, the totals being:

| | | | |
|---|---|---|---|
| Exports and imports.. | 415 522 | short tons, valued at | $8 451 414 |
| Domestic ..... | 2 025 434 | " " " " | 31 313 990 |
| Local ..... | 5 393 317 | " " " " | 25 116 602 |
| Totals..... | 7 834 273 | short tons, valued at | $64 882 006 |

*Grays Harbor.*—The most important of the secondary harbors of the Coast is Grays Harbor, forty-five miles north of the Columbia. It is a pear-shaped body of water nearly 100 sq. miles in area. It is really a vast mud flat, much of it being bare at low tide, and the channel to the upper portion where the Towns of Hoquiam, Aberdeen, and Montesano are located, has to be maintained by dredging. Extensive jetty work has been built and is now in progress to develop a channel over the bar. The port has three railroads. Its importance depends primarily on its lumber trade, and it is the largest cargo lumber port in the world. The Government has appropriated about $2 400 000 for improvement of the harbor and bar. The commerce for 1910 amounted to 670 000 tons, valued at $6 000 000 of which more than 80% represented lumber products.

*Puget Sound.*—In their physical characteristics, the Puget Sound ports are much alike, the water being very deep, anchorage ground scarce owing to depth, the tidal range large, and the teredo active. As a rule, there is absolute freedom from obstructions in the channels of approach. Pilots and tugboats (except the latter for sail boats)

are unnecessary, though pilotage on the larger vessels is customary. In all cases the streams leading into the harbors from the Cascades bear heavy loads of silt, and have filled up the estuaries for long distances. The tide flats thus built up have proven an invaluable asset, for they have made up to some extent the deficiency of low flat lands necessary for industries and terminal facilities. South of Deception Pass rock is scarce, but north of that point it outcrops everywhere, and in some instances forms dangerous obstructions. The whole

TABLE 4.—Freight Traffic.

| Articles. | Amount (customary units). | Amount, in short tons. | Valuation. | Rate per ton-mile. |
|---|---|---|---|---|
| Exports and Imports. | | | | Mills. |
| Bags and burlap | 5 230 tons | 5 230 | $488 934 | 0.694 |
| Cement | 80 852 bbl. | 19 202 | 119 061 | 0.122 |
| Coal | 18 733 tons | 18 733 | 47 313 | 0.694 |
| Coke | 4 021 tons | 4 021 | 14 187 | 0.308 |
| Fibers | 1 703 tons | 1 703 | 190 313 | 0.793 |
| Flour | 283 679 bbl. | 27 800 | 1 186 654 | 0.638 |
| Fire brick and clay | 7 149 tons | 7 149 | 33 848 | 0.191 |
| Iron (pig and bar) | 8 774 tons | 8 774 | 137 454 | 0.184 |
| Lumber | 122 711 000 ft. b. m. | 159 524 | 1 505 497 | 0.620 |
| Machinery | 50 tons | 50 | 1 445 | 0.694 |
| Rice | 2 082 tons | 2 082 | 90 662 | 0.851 |
| Sulphur | 7 630 tons | 7 630 | 124 643 | 0.638 |
| Wheat | 5 120 826 bushels. | 153 624 | 4 511 403 | 0.421 |
| Total | | 415 522 | $8 451 414 | |
| Domestic. | | | | |
| Lumber | 317 932 977 ft. b. m. | 413 313 | $4 133 130 | 3.331 |
| Logs | 48 000 000 ft. b. m. | 96 000 | 288 000 | 1.50 |
| Oil | 6 900 000 bbl. | 1 159 200 | 5 477 600 | 2.50 |
| Miscellaneous | 356 921 tons | 356 921 | 21 415 260 | 5.00 |
| Total | | 2 025 434 | $31 313 990 | |
| Local. | | | | |
| Coal | 3 424 tons | 3 424 | $23 968 | 20.00 |
| Fish | 13 223 tons | 13 223 | 1 586 760 | 20.00 |
| Flour | 107 397 bbl. | 10 525 | 526 250 | 20.00 |
| Fruit | 3 478 tons | 3 478 | 208 680 | 40.00 |
| Grain | 728 413 bushels. | 18 116 | 391 525 | 25.00 |
| Hay and feed | 11 483 tons | 11 483 | 172 245 | 20.00 |
| Hops | 135 tons | 135 | 27 000 | 50.00 |
| Live stock | 22 001 heads | 4 592 | 918 400 | 35.00 |
| Logs (towed) | 1 035 295 704 ft. b. m. | 2 070 591 | 6 211 773 | 5.00 |
| Lumber | 13 930 960 ft. b. m. | 18 110 | 181 100 | 20.00 |
| Manufactured iron and steel | 7 369 tons | 7 369 | 257 915 | 25.00 |
| Merchandise | 55 146 tons | 55 146 | 5 514 600 | 50.00 |
| Miscellaneous | 70 247 tons | 70 247 | 4 214 820 | 50.00 |
| Oil (barged) | 1 872 582 bbl. | 314 594 | 1 343 782 | 30.00 |
| Piles (towed) | 14 017 887 lin. ft. | 280 358 | 1 121 432 | 12.50 |
| Potatoes | 30 610 000 lb. | 15 305 | 306 100 | 30.00 |
| Sand and gravel (barged) | 1 059 133 cu. yd. | 1 592 671 | 796 335 | 8.00 |
| Shingles | 2 193 733 bundles. | 38 390 | 1 151 700 | 28.00 |
| Stone (barged) | 562 364 cu. yd. | 843 550 | 84 355 | 10.00 |
| Wood (barged) | 14 603 cords | 21 905 | 54 762 | 15.00 |
| Wool | 105 tons | 105 | 23 100 | 50.00 |
| Total | | 5 393 317 | $25 116 602 | |

conformation of the Puget Sound country is the result of glacial action, and many of the lakes and bays are simply the gouged out paths of glaciers, while the shores are masses of the most heterogenous material. So irregular and broken with indentations and islands is the Sound area that tidal currents and stages are wholly irregular. Tidal predictions are possible only as a result of long observation, and are stated in the Government tables in terms of retardation behind the Port Townsend prediction.

With this general reference to the ports of Puget Sound, a somewhat detailed description will be given of its principal port, Seattle, Wash. Seattle Harbor means primarily Elliott Bay, a not very large indentation into the east shore of the Sound. Between its extreme limits, West Point and Alkali Point, the pier-head line is 10 miles long. The really practical limits of the harbor, as far as the near future is concerned, may better be taken as Duwamish Head and the southern point of Magnolia Bluff, directly opposite. Within the line joining these points is Elliott Bay proper, quite similar in contour (though slightly smaller in area) to Commencement Bay, on which the port of Tacoma is situated. The area of Elliott Bay, as thus limited, is 4.3 sq. miles, and its shore line (pier-head line), not counting slips and waterways, is 6.5 miles. Over this entire area there is ample depth for the heaviest shipping. There is never any ice or rough weather to disturb deep-sea vessels, though southwest winds disturb small vessels in the reach south of Smith's Cove, as north winds do those on the south side of the harbor. The tidal currents are too slight to be drawbacks of any moment.

The water-front development is most pronounced along that portion where the city began its growth. For upward of a mile the entire frontage is in active use. There are some important piers, which, as a rule, are run out at very oblique angles with the shore in order to secure the necessary length without getting out to prohibitory depths. At the north is the important pier of the Great Northern Railway, and near it a still unimproved waterway, Smith's Cove, 1 mile long and 400 ft. wide, which is destined to important use in the growth of that part of the city. On the south side of the harbor, the delta of the Duwamish River has been filled in, except for the reservation of two waterways, the East and the West, inclosing a tract of land popularly known as Harbor Island, from which great things are expected in

the future growth of the city. As the plan will finally work out, East Waterway will be practically a slip, about 1 mile long and 750 ft. wide, with slips and quays on the two sides. The east side of the Waterway is really a part of the main water-front. West Waterway will be 900 ft. wide and will be the outlet of the Duwamish River.

The valley of the Duwamish furnishes the single large tract of bottom land directly adjacent to the harbor, and it must naturally develop into an important industrial center. Plans are perfected and well under way, with a large part of the funds already provided, for straightening the river and excavating a channel 4 miles up the valley to a bottom width of 150 ft. and a low-water depth of 16 ft. The utility of this work in the industrial development of the city is bound to be great.

Such is what may be termed Seattle's outer, or tidal, harbor, with a perimeter, including the three main waterways, of 12.5 miles east of Magnolia Bluff and Duwamish Head, and this is susceptible of almost indefinite extension by pier and slip construction. Every foot of this frontage is served, or readily capable of being served, by railroads, and the possibilities of expansion are all that are likely to be required for a century to come. The extent of existing wharf construction is such as to give about 14 500 lin. ft. of berthing space.

In addition to this magnificent gift of Nature, Seattle has another absolutely unique among the sea ports of the world—what may be called her inner harbor, soon to be opened to the commerce of the seas. The glaciers, in carving out the picturesque topography of this city, left two remarkable troughs or basins, bordered by hills from 200 to 500 ft. high. These basins are just enough above sea level to keep out the tides, and their waters, therefore, are fresh. Their own levels differ by only about 10 ft., the larger lake being the higher. Nearly all the area of both lakes is deep enough for the heaviest shipping; and all that Nature has left undone to make it accessible from the sea is to provide a lock and an artificial channel from Lake Union to the Sound, and a channel between the lakes. This work is being done by the Government and the local community. A channel, 100 ft. wide on the bottom and 36 ft. deep, will be provided, with two parallel locks, one 825 ft. long and 80 ft. wide, interior dimensions, and the other 150 ft. long and 30 ft. wide, for small boats. Salmon Bay, a tidal slough between Lake Union and the Sound, will be raised by the lock

and dam to the level of Lake Union, and Lake Washington will be lowered to the same level, thus giving a uniform level from the lock to the remotest corners of Lake Washington. The canal right of way will admit of double the present proposed width, should commerce ever demand it. The bridges will have 30 ft. clearance, except one railroad bridge which will remain open when not in use. The fluctuation of level will not exceed 2 ft. The lakes are free from obstructions and do not freeze. Incidentally, the lowering of Lake Washington will absorb the floods of its water-shed and of Cedar River, and thus furnish a needed relief to the floods of the Duwamish, besides draining extensive marsh areas around the shore and making them available for industrial use.

There has been much speculation as to the value of this proposed improvement work. On the face of it, it would seem to furnish one of the most ideal opportunities that any port ever had. Think what it would mean to Los Angeles, if, instead of spending tens of millions for a narrow and restricted tidal harbor, she could, at an expense of $4 000 000 or $5 000 000, open up 40 sq. miles of fresh, deep water with a shore line of 100 miles. But at Seattle it does not mean what it would at Los Angeles. The rare perfection of the harbor of Elliott Bay places even this wonderful fresh-water harbor at a discount, as far as over-seas shipping is concerned. Still, its incomparable advantages are bound to tell. Absolute freedom from tidal fluctuation and currents, freedom from the teredo and, therefore, assurance of permanence in subaqueous timber construction, the beneficial effect of fresh water on the hulls of vessels, and the access which the lakes give to all sections of this district, are advantages which will not go unused. The first and immediate effect will be on small-boat traffic, lighterage, and the like, and a complete readjustment of this class of traffic may surely be expected. Salmon Bay and Lake Union will become great docks in the very heart of the city, while Lake Washington will offer thousands of acres of shore lands adapted to manufacturing. Gradually, larger shipping will follow, particularly in quest of lumber cargoes. Already inquiries are being made for sites for the fishermen's fleet and the yachting and motor-boat fleets. The large number of vessels which ply these northern waters, but which lie idle in winter, will find ideal refuge here. It will be strange if even the Navy Department does not take advantage of these fresh,

sheltered waters to lay up such of its vessels on this Coast as remain for a time out of commission. The ship-building industry of the entire Northwest ought to center at Seattle. Therefore, in spite of the unrivaled attractions of Elliott Bay, Seattle's future fresh-water harbor seems bound to become a priceless adjunct to the city's growth.

The natural perfection of Seattle's outer harbor is in no way better shown than by the remarkable fact—probably unique among American harbors—that no Federal appropriation has ever been made for its improvement. The only expenditure, not by direct private initiative, has been the development of the East and West Waterways and Harbor Island, and this has cost, in round numbers, $3 000 000.

The development of the inner harbor will have cost, when completed, exclusive of bridges and other crossings, approximately $4 250 000, of which the Government will have contributed about $2 750 000, and local agencies (State and County) about $1 500 000.

On the west shore of the Sound, directly opposite Seattle, and concealed in a deep inlet, with narrow, tortuous approaches, yet safe for the heaviest ships and protected by strong defenses, is one of the most interesting spots in the city. It is the Naval Station of the North Pacific Coast, destined to expansion, because of its superior advantages, into one of the greatest, if not the greatest, in the United States. It is mentioned in this connection with particular reference to its dry-dock facilities, which are often utilized by commercial vessels. There are other dry docks on the Sound, particularly the Heffernan Dock on East Waterway, Seattle, but no others of a capacity for docking the largest vessels.

Tacoma, the second port in importance on the Sound, is 30 miles south of Seattle, on Commencement Bay, similar in form and position to Elliott Bay. The tide flats have been built up by deposits from the Puyallup River, as those of Elliott Bay were by the Duwamish. Two waterways have been laid out, and one of them, the City Waterway, has been excavated into these flats. An attempt was made to excavate the other—the Puyallup Waterway—but the excessive deposits of silt brought down by the river (greatly augmented since 1906 by the bodily diversion to the Puyallup, through natural causes, of the White River from its former outlet into the Duwamish) made it impossible to secure or maintain the desired depth. The principal dockage facilities consist of a long quay dock on the west

side of the Bay, the City Waterway, and a slip excavated by the Chicago, Milwaukee and Puget Sound Railroad for its own use. The aggregate berthing space is 14 500 lin. ft. The business of the port has been greatly promoted by the location there of the principal shipping facilities of two important railway systems, and it now crowds closely on that of Seattle.

There are five other ports on the Sound worthy of particular note. These are Olympia, at the extreme southern end, and formerly important as the first point where travel from the Columbia touched the Sound—a very important circumstance before there were any good roads or railroads in the country. Everett is 30 miles north of Seattle, and is at the point where the Great Northern Railway reaches tidewater. It lies at the mouth of the Snohomish River, and is a port of considerable importance. Bellingham is another of the important secondary ports, and the farthest north of those considered in the paper. Anacortes is a flourishing port on Fidalgo Island, reached by a branch line of the Great Northern. Port Townsend is the chief port on the Olympic Peninsula, and has a peculiar importance quite apart from its commercial business, which is slight. It stands at the gateway to Puget Sound, where the great defenses are, it is the headquarters of the Customs District of the Sound, the location of the Quarantine Station and Marine Hospital, the base for nearly all marine reckonings pertaining to the Sound, and, in other respects, an artificially important port. Its location is such, however, that, despite its excellent harbor, there is no reason to expect that it will ever develop an important commerce of its own.

The expenditures, in round numbers, already made or authorized, by the Government in improving the several harbors of the Sound, are as follows. There have also been local expenditures in most of them, but these amounts, except in the case of Seattle, are difficult to determine.

| | |
|---|---|
| Olympia | $160 000 |
| Tacoma | 320 000 |
| Seattle (Canal) | 2 750 000 |
| Everett | 700 000 |
| Bellingham | 60 000 |
| Total | $3 990 000 |

The commercial statistics of the Sound ports are given in Table 5, the totals being as follows:

| Port. | Short tons. | Valuation. |
|---|---|---|
| Seattle | 2 371 628 | $96 048 996 |
| Tacoma | 1 299 206 | 61 315 442 |
| Other ports | 2 244 889 | 28 892 495 |
| Entire Sound | 5 915 723 | $186 256 933 |

TABLE 5.—Freight Traffic, 1910.

| Article. | Amount (customary units). | Amount, short tons. | Valuation. |
|---|---|---|---|
| **Port of Seattle.*** | | | |
| Lumber | 100 795 173 ft. b. m. | 201 590 | $1 562 567 |
| Grain | 1 675 745 bushels. | 50 272 | 1 501 595 |
| Flour | 616 310 bbl. | 60 398 | 2 619 887 |
| Fodder | | 30 109 | 722 925 |
| Fruit | 148 219 cases. | 3 705 | 256 072 |
| Coal | | 637 851 | 2 706 147 |
| Building material | | †110 292 | 1 475 480 |
| Merchandise | | 1 063 155 | 55 522 586 |
| Oil | †616 133 bbl. | 123 227 | 2 372 949 |
| Miscellaneous | | 91 029 | 27 308 788 |
| | Total | 2 371 628 | $96 048 996 |
| **Port of Tacoma.** | | | |
| Lumber | 268 221 170 ft. b. m. | 404 427 | $3 087 293 |
| Grain | | 137 412 | 4 056 344 |
| Flour | | 125 589 | 5 084 121 |
| Fodder | | 19 747 | 271 730 |
| Fruit | | 4 918 | 497 400 |
| Coal | | 49 565 | 151 292 |
| Oil | 303 890 bbl. | 60 778 | 528 728 |
| Building material | | 163 022 | 1 008 541 |
| Merchandise | | 170 473 | 31 290 942 |
| Miscellaneous | | 163 275 | 15 339 051 |
| | Total | 1 299 206 | $61 315 442 |
| **Puget Sound, Seattle and Tacoma Excluded.** | | | |
| Lumber | 1 196 745 204 ft. b. m. | 1 686 207 | $10 503 009 |
| Grain | | 23 489 | 626 875 |
| Flour | | 4 283 | 133 621 |
| Fodder | | 12 705 | 234 012 |
| Fruit | | 9 021 | 542 393 |
| Coal | | 16 431 | 67 793 |
| Oil | 15 410 bbl. | 3 142 | 24 527 |
| Building material | | 178 230 | 537 253 |
| Merchandise | | 136 511 | 10 084 509 |
| Miscellaneous | | 174 870 | 6 138 503 |
| | Total | 2 244 889 | $28 892 495 |

* Compiled from the Harbor Master's Report.
† Computed in part.

*Vancouver, B. C.*—The chief Canadian port, Vancouver, B. C., is in the vicinity of the mouth of the Great Fraser River, though actually not in the valley of that stream. More fortunate than Portland, Vancouver has been able to flank a troublesome river with its floods and shoals while still taking advantage of its valley on its rail route through the mountains. The port has been built in a land-locked bay called Burrard Inlet, surrounded on nearly all sides by towering hills which give the location a most beautiful setting. The area of the entire inlet inside the entrance is 23.6 miles, with a shore line of upward of 50 miles; but the port proper, as at present developed, utilizes only a small fraction of this. The shores are mainly of rock formation; the tidal range is 11 ft. mean and 16.4 ft. extreme. There is no ice, and the harbor is perfectly sheltered and has good anchorage.

The port facilities, as developed so far, are mainly on the south side of the east 5.5 miles of the Inlet. The portion of the Inlet comprising the harbor is about 1⅓ miles in width, connecting with the Gulf of Georgia on the west and the remainder of the Inlet on the east by two narrow channels designated First and Second Narrows, respectively. These Narrows were formed by the deposit of gravel, sand, and small boulders brought down by mountain streams on the north side of the Inlet and deposited in the shape of extensive bars. The Narrows are deep, but only about 500 ft. in width. Navigation through them is seriously handicapped by strong tidal currents, which, at the First Narrows, reach as high as 8 knots per hour at spring tide, and are such a menace to navigation that the Dominion Government has undertaken to widen the entrance by dredging to 1 200 ft. The improvement will not affect the current perceptibly, but will give more leeway for the navigation of ships. In most portions of the harbor the tidal currents interfere seriously with the berthing of ships.

*New Westminster.*—Ten miles south of Vancouver on the Fraser River, and 16 miles above its mouth, is the Town of New Westminster, which is taking active steps to develop port facilities for deep-sea shipping. The Fraser is a large river, not unlike the Columbia, but with a channel less difficult to improve and maintain. The ordinary tidal range at the port is only 5 ft., but the range between high and low water in the river is 14 ft. Reference will be made in another place to the steps being taken to develop this port.

*Victoria.*—This has been an important port in the past, and is so still, though its commercial business is not large. It is the chief port of Vancouver Island and on it is located the capital of British Columbia. The commercial port is on a small land-locked inlet with bald rocky shores. A few miles to the west is the celebrated Esquimault, an excellent port, strongly defended, and, prior to 1905, the headquarters of the British North Pacific Naval Squadron.

*Prince Rupert.*—This harbor is on an island within a well-sheltered inlet on the "inside passage" to Alaska, a little north of the mouth of Skeena River, the valley of which stream is the route of the western division of the railroad. The area of the entire inlet in front of and back of the island is about 27 sq. miles, and that of the shore line is about 80 miles. The tidal range is large, the maximum being 27 ft. and the mean about 14. The harbor is perfectly sheltered and is free from ice.

The port is very new, and its development has only begun. It now has about 2 700 ft. of berthing space, of which 600 ft. belongs to the Provincial Government and the rest to the Grand Trunk Pacific. It has a sectional dry dock 600 ft. long. The newness of the port and the fact that rail connection east is not yet opened, give little as yet for comparison with other ports. Its record lies all in the future.

The promoters of this important terminal enterprise adopted the almost unique course in civic growth of laying out their city before its occupancy by settlers began. It has been scientifically planned by artists of national reputation, and, if the plans are followed, it will be spared the disfiguration characteristic of most American cities.

## III.—Notable Engineering Works.

The development of the ports of the Pacific has evolved a great range of engineering problems, some of which are of unusual magnitude, difficulty, and cost. A brief reference to the more important will be given. They include:

(1) Rock removal.
(2) Breakwater construction.
(3) Jetty construction.
(4) Lock construction.
(5) Dredging.
(6) Sea-wall and pier construction.

*Rock Removal.*—This class of work has been confined mainly to San Francisco Harbor and to ports north of the Strait of Juan de Fuca. In San Francisco the removals have been almost entirely of isolated rocks, some of which did not originally come to the surface. Another example of sunken rock removal is that in Roche Harbor, San Juan Island, Washington. Ledge rock removal has been and is being extensively carried on in British Columbia ports.

The various rock removals in the vicinity of San Francisco include the following: Blossom Rock, directly in the channel leading from Golden Gate into the harbor; Rincon Rock, now within the pier-head line and covered with a wharf; Arch Rock; the two Shag rocks; Centissima Rock, in the Bonita Channel just outside the Golden Gate; and Noonday Rock, 33 miles at sea opposite the harbor entrance. Of these removals, Blossom Rock was most important. The method of removal originated with General Alexander of the U. S. Corps of Engineers, and the plans were very carefully worked out. They included the building of a coffer-dam on top of the rock, which rose to within 6 ft. of low water, unwatering the coffer-dam, sinking a shaft into the bed of the rock, and then excavating an immense chamber into which was to be placed the explosive. It was expected that the strong tidal currents would remove most of the shattered rock, and that the remainder would be scraped into deep water. The contractor sank and securely fastened to the rock a timber crib which served the double purpose of a platform and a protection to an iron tube 6 ft. in diameter and 14 ft. high, which was placed through the center of the crib. A water-tight connection was effected with the rock by the use of a liberal quantity of cement. The tube was then unwatered and a shaft sunk to Reference 30 ft. below low water. During the progress of sinking the shaft so much leakage occurred through the rock that it was found expedient at two different times to telescope smaller tubes into the shaft and secure water-tightness by cementing the annular space between the rock sides of the shaft and the tubes. At a depth of 14.5 ft. into the rock the leakage became nominal, and the chamber was then easily excavated. The floor of the chamber was at Reference 31.5 ft. below low tide, the axes being 135 and 55 ft., respectively. The roof conformed to the general shape of the surface of the rock and had a thickness varying between 14 and 18 ft. Four stone pillars were left at the shaft, and timber supports were distributed throughout the chamber.

The explosive used was nitrate of soda, of which 4 300 lb. was placed in 38 wooden, ale barrels and in 7 old, boiler-iron tanks. The barrels were distributed around the edge of the chamber, and the tanks were scattered at about equal intervals on the floor. The blast took place on April 23d, 1870. The explosion was a pronounced success, but the chamber had not been made large enough to engulf the broken-up roof, and the hope that the current would remove the débris was not realized. The subsequent removal of débris, by scraping the blasting, cost as much as all the previous operations, up to and including the blast.

A contract for removing an additional 6 ft. from Blossom Rock in order to give a 30-ft. depth at low water, was let in November, 1902, for $45 142. The quantity of rock to be moved was 4 630 cu. yd. The contractor drilled a few holes, but abandoned the process for surface blasting and dredging the broken-up rock into deep water. The official reports do not give the reasons for the adoption of this method, but it may be conjectured that at least one reason was the shattered state of the rock due to former operations.

On January 2d, 1863, the clipper ship, *Noonday,* was wrecked on an uncharted rock in the Pacific opposite Golden Gate, and a demand arose for its removal. A search for the rock was made by the U. S. Coast Survey, and a pinnacle 5 ft. square on top, with 19½ ft. of water over it at low tide, was found and buoyed. In 1874 a contract was awarded to Mr. Edward Moore, of Portland, Me., for removing the menace to navigation, at an upset price of $20 000. Being in the open sea and subject to adverse weather conditions, the work entailed more hazard than similar work in a sheltered harbor. At first it was proposed to sink an encircling chain to a depth of 50 or 55 ft., at low tide, to which were to be attached packages of nitro-glycerine, but when operations were commenced the diver discovered below the required depth a cavity 10 ft. deep in one side of the rock. The plan was altered immediately to put the entire charge of explosive in the cavity. The charge was fired May 7th, 1875, and proved an entire success.

The method of subaqueous rock removal known as "bulldozing" apparently had its origin in San Francisco. It consists simply in placing high explosives in contact with rock surface and exploding it there without drilling or tamping. The shattered surface is then scraped away and the process repeated. Although the use of explosives

by this method is excessive, the expense of drilling is saved. The results, so far, however, do not seem to commend the method on the score of either efficiency or cost. In 1907-08 a submerged rock at the entrance to Roche Harbor, Puget Sound, was removed by this method. The volume of the portion to be removed was 1 500 cu. yd., and the contract price was $23 460; but the work probably cost the contractor more than this. The official Government report says that "the method, as applied in this case, did not prove satisfactory, and the contractors state that if they had the work to do over they would drill the rock."

In the work in San Francisco Bay, where the masses to be removed were considerable, the contract price per cubic yard was less than $10; as, for example, the work on Rincon Rock, before it was abandoned, cost $9.06 per cu. yd. for the removal of 4 357 cu. yd.; and the cost of removing 32 000 cu. yd. on the Shag and Arch Rocks was $7.93 per cu. yd.

The subaqueous basaltic rock excavation at the eastern end of Victoria Harbor was performed by the drilling method. The single drill was mounted on a platform float that could be raised clear of high tide by steam power spuds. Steam was furnished from boilers on a barge. Thirty-two holes were drilled at one setting of the raised platform. The holes were 2.5 in. in diameter, drilled to a depth of 2.5 ft. below grade (20 ft. at low water), and spaced 3 by 3 ft. The actual cost for drilling and blasting only was $6.17 per cu. yd., without interest, depreciation, or plant renewal.

The blasting in Vancouver Harbor will be a more delicate operation, as it will be carried on in close proximity to constructed piers. Holes 3 in. in diameter, spaced 5 by 5½ ft. centers, will be drilled to a depth of 3 ft. below the required grade line (36 ft. at low tide), and shot off in series. It is expected that 1½ lb. of dynamite per foot of hole will be used. The estimated cost for drilling and blasting is $5.60 per cu. yd. Dredging the broken rock will approximate an additional $1 per cu. yd. The Vancouver rock is a sloping sandstone ledge overlaid with from 3 to 7 ft. of gravel, hardpan, and disintegrated sand rock.

*Breakwater Construction.*—As an example of breakwater construction strictly speaking—that is, work done for the primary purpose of protecting anchorage areas or harbor entrances from ocean storms—the San Pedro Breakwater at Port Los Angeles is the most important

on the Coast. As finally constructed, it has a length of 11 000 ft. and extends first on a curve and then in a straight line easterly from Point Fermin, thus giving shelter against south and southwest exposure and in particular completely protecting the entrance to the inner harbor which is behind the inner end of the structure. The breakwater is built entirely of rock, except a concrete block 40 ft. square and 20 ft. high at the outer end. The base of this block is 3 ft. below the low-water plane. The construction of the breakwater was effected from a double trestle carrying tracks of standard gauge. The substructure was built to the elevation of low water and consists of a central portion of stone weighing 1 ton or less, with larger stones on the side slopes. The superstructure is 38 ft. wide at the bottom and 20 ft. wide at the top (14 ft. above low water), with stepped sides of huge blocks of stone placed by cranes. On the ocean side the stones weigh 16 000 lb. or more; on the harbor side, 6 000 lb. or more. The space between the sides is compactly filled with rock of all sizes, and the top is finished with large stones. The side blocks have been placed with such care that they seldom depart more than 6 in. from exact position.

*Jetty Construction.*—As used in this connection, the term, jetty, applies to a structure designed to serve the primary purpose of concentrating and directing ocean currents to develop scouring effects over shoal bars, and the secondary purpose of protecting such crossing from storms, as far as their location for the first purpose will permit. They are, therefore, a combination of training dike and breakwater. There are four prominent examples on that portion of the Pacific Coast considered in this paper, all of which are north of San Francisco, namely, Humboldt Bay, Coos Bay, the Columbia River, and Grays Harbor. There are also numerous minor examples, as at San Diego, Los Angeles, and Oakland. The principles involved are essentially the same in all, though varied in application, of course, to suit the conditions of each case. The Columbia Jetty far exceeds any of the others in importance and in the magnitude of the work, and the description will be limited to this one example.

As originally projected, the jetty extends in a west-by-northwest direction 4½ miles from the east side of Point Adams across Clatsop Spit and out to deep water. The jetty was to be built of large size stone on a brush mattress and raised to the level of low tide. Later,

the project was changed to raise it to high tide, and four groins were to be built from the north side to arrest scour. Work was begun in 1885 under an estimate of $3 710 000, and was completed ten years later at half the estimate. The depth over the bar had increased, in the meanwhile, from 21 to 31 ft., and the work seemed to have accomplished its purpose perfectly.

Unfortunately, the bar began rebuilding itself, the depths shoaled, and several years later there was only the original depth of 21 ft., and it seemed to be necessary to start all over. A new project was adopted, extending the jetty 3 miles farther, or somewhat beyond the longitude of Cape Disappointment on the north shore. The work was to be supplemented by dredging over the bar. This extension is now nearing completion and has resulted in a present depth of from 25 to 27 ft. A permanent depth of 30 ft. is sought.

This work, it is scarcely necessary to remark, is probably the largest and most difficult of its kind ever attempted, and has evolved some of the most ingenious and elaborate methods for overcoming difficulties in the whole range of engineering. The two great obstacles to be overcome in the execution of the work are the storms and the teredo, and it is the fact of the storm that gives the teredo its "inning." The roughness of the sea precludes the use of barges for dumping rock, thus necessitating a trestle, and the trestle piling is the particular delight of the teredo, which puts it out of commission in from 10 to 20 months. The rebuilding of the trestle on the rock of the jetty, which has been repeatedly necessary, and the methods resorted to in order to arrest the work of the teredo, have taxed the resources of the engineers to the utmost.

The jetty itself, as now being built, consists of a bed course of small rock as a substitute for brush mattress, it being found impracticable to use the mattress beyond the shoal depths of Clatsop Spit. On the foundation so provided heavier rock is deposited, and the whole is covered on the seaward slope with very heavy rock ranging in weight from 6 to 16 tons per piece. Even these enormous masses are displaced by the storms, and the embankment is progressively shaken down during each winter season.

The long continuance of this work has evolved a very efficient system for its management—one which it would be difficult perhaps to improve on, because every feature is the result of actual experience.

The pile-driver is a study in itself. The support of the pile trestle on its bed of huge boulders, the arrangement of the movable car beds and of the cars themselves for the quick handling of the rock, the systematic organization of the work, which moves with the regularity of clockwork, and, finally, the rational division of the work between the contract and day-labor systems, assigning to each the share it is best adapted to carry out—all combine to make this great work well worthy the attention of the engineers of the United States.*

*Lock Construction.*—Locks are an important adjunct of port development in English ports, where they are applied to overcome the drawback of excessive tidal fluctuation. They are nowhere so used on the American Continent, but they are about to be used in the Port of Seattle for the purpose of effecting a very large extension of the harbor, as previously explained. The lock which separates the main harbor from the Sound is located at the outlet of Salmon Bay, 1 mile inland from deep water, at a sheltered and easily defended point called the Narrows.

The lock is really a double structure, comprising a large chamber for heavy shipping, log rafts, etc., and a small chamber for the use of the mosquito fleet. It is certain that small-boat traffic through the canal will be large, and the plans provide a small, quick-operating lock for its use so as to avoid the slower and more expensive operations of the larger lock. It is considered that this provision will prove one of the most useful features of the canal. A similar arrangement is provided on the Manchester Ship Canal, in England. It seems to the writer that if the Panama Canal plans are open to any important criticism it is in not providing a flight of smaller locks. To operate those immense locks for the passage of small boats cannot fail to prove a great waste of energy and time and possibly an interference with traffic.

Returning to the Lake Washington Canal lock: a description of that structure, which is now in process of erection, will be given. The larger lock will be 825 ft. long and 80 ft. wide, or large enough to admit without breaking the large log rafts which are certain to constitute an important part of the traffic. The sill of the lower gate will be at Reference 25 ft. below extreme low tide, 29 ft. below

* Those who desire a detailed description are referred to an article on page 109 of *Engineering News* of July 30th, 1908.

mean lower low tide, and 35.67 ft. below mean sea level. The sill to the upper gates will be 36 ft. below the low-water level of the canal and 38 ft. below the high-water level. The lock will be supplied with intermediate gates which may be used to divide the chamber into lengths of 350 and 475 ft., respectively, for convenience and economy of water in the passage of shorter vessels. There will be guard gates at the two entrances, and a movable dam at the upper end for emergencies arising from accidents. The small lock will be built on the south side of the large one, and will be 150 ft. by 30 ft. and 16 ft. deep over the miter sills.

The lock walls will be of mass concrete, gravity section, straight-front face, with a toe projecting into the lock chamber, and stepped back. The filling culverts will be of large elliptical section, running the full length of both walls, and connecting with the chamber by numerous side culverts at right angles to the axis of the lock. The controlling culvert gates will be of the Stoney type in the large lock and of some form of cylindrical balanced valves in the small one. It is expected to fill or empty the chamber of the big lock in 8 min.

The lock gates will be of steel, with parallel straight faces except near the front and back edges. All gates will be provided with air chambers to relieve the strain on anchorages and to permit of floating the guard gates out of position for repairs and painting. The main gates will be reached by closing the guard gates and pumping out the chamber.

The most interesting detail of the lock, and the one on which there will be most divergence of opinion, is the lock floor. The ever-recurring debatable question in lock construction arises here—shall the floor be made strong enough to resist an upward hydrostatic pressure, or shall it be a mere pavement to protect the underlying material from scour, reliance being placed on the cut-off walls to prevent leakage? The lock floor is not yet determined on, the decision being held in abeyance until an examination can be made of the foundation material, when the lock coffer-dam is unwatered.

The lock when completed will be exceeded in size, on the American Continent, by the Panama Lock only; it will be on a par with the new Sault Lock, greater in some particulars, but less in others, and will entail the solution of more difficult engineering problems than the one at the Sault. It will rank with the greatest European locks, and take

its place in shipping and engineering circles as one of the very prominent structures of its class.

The principal data relating to the canal are as follows:

| | | |
|---|---|---|
| Extreme low tide in Puget Sound | Reference | 0 |
| Mean lower low tide, " " | " | 4 |
| Mean low tide, " " | " | 6.89 |
| Mean sea level, " " | " | 10.67 |
| Mean high tide, " " | " | 14.50 |
| Mean higher high tide, " " | " | 15.23 |
| Extreme high tide, " " | " | 18 |
| Present level of Lake Union | " | 25 |
| " low-water level in Lake Washington | " | 33 |
| " high-water level in Lake Washington | " | 38 |
| Proposed low-water level in canal | " | 24 |
| " high- " " " " | " | 26 |
| Length of large lock between quoins | 825 | ft. |
| Width " " " " " | 80 | " |
| Depth on lower sill at extreme low tide | 25 | " |
| " " " " " mean sea level | 35.67 | " |
| " " upper " " low water | 36.00 | " |
| " " " " " high " | 38.00 | " |
| Lift of lock from extreme low tide to high water | 26.00 | " |
| " " " " " high " " low " | 6.00 | " |
| Depth of water in main body of Lake Union | 40.00 | " |
| " " " " Lake Washington | 40.00 to 200.00 | " |
| Length of canal from deep water in Puget Sound to deep water in Lake Washington | 8.00 | miles |

*Dredging.*—Pacific Coast ports are no exception to the almost universal need of dredging operations to secure full navigable depths in channels and docks. Seattle and Tacoma come nearest to being exceptions, but even in these ports waterways have been created artificially by dredging. At Seattle, for example, a great deal of work has been done in reclaiming the tide flats of the Duwamish Delta, and creating artificial waterways there, while now extensive operations are in progress in excavating the Duwamish Waterway and the Lake

Washington Canal. None of these operations was necessary, however, in the main harbor, which everywhere had ample depth. At the other extreme is Los Angeles, where the harbor itself is being built almost entirely from excavation. Differing from either of these is Portland, where the channel of approach to the harbor requires very extensive and continuous dredging, not only for original deepening, but for maintenance of depth. San Diego, Oakland, San Pablo Bay, Grays Harbor, and several of the ports in Puget Sound, have been thus improved by excavation. As a rule, this work has been done with Government appropriations, though in some ports, such as Portland, and, more recently, Los Angeles and Seattle, local funds are being contributed to the work. Now that the reclamation of tide flats is becoming so profitable an enterprise, dredging will be resorted to more than ever, the operation serving the double purpose of excavating slips and channels and filling the abutting lands.

The plant used in this work embraces every practical variety of dredging machinery, from the heaviest sea-going hopper or suction dredge to ordinary steam shovels loaded on scows. The Pacific Coast dredging fleet, taken as a whole, both publicly and privately owned, is a formidable one. In the more localized operations electricity is sometimes used as the motive power. Oil is used extensively as fuel. All varieties of excavation are encountered, from the lightest alluvium to indurated clays that border closely on soft rock. In California great use is made of the clam-shell dredge, with enormously long booms, designed for levee building on the Lower Sacramento and San Joaquin Rivers, and on some tributaries of the larger stream great hydraulic dredges are used to glean out the particles of gold which the improvident miner wasted as he sluiced down the auriferous hillsides a generation and more ago.

It is needless to describe in any detail these dredging operations, for they present nothing sufficiently characteristic to mark them from those with which engineers are familiar in the East. It will be of interest, however, to refer briefly to two of the dredges. The latest sea-going hopper dredge built by the United States Government is the *Chinook,* for use on the Columbia River Bar. It is a converted transport, 445 ft. long, of 5 590 gross tonnage. The transformation was made in 1902, but many alterations and repairs have been made since that time. The dredge has two 20-in. pumps and two

bins of a total capacity of 3 600 cu. yd. Its performance during the fiscal year ending June 30th, 1911, was:

| | |
|---|---|
| Days worked | 160 |
| Cubic yards excavated | 722 431 |
| Total operating cost | $58 943.15 |
| Cost per cubic yard | $0.08159 |

Probably the most effective dredging plant for all purposes on the Pacific Coast is the *Frühling,* built in Germany in 1906 at a cost of $275 000, exclusive of duty and cost of steaming to British Columbia. It is the property of the Department of Public Works, of Canada, and operates on the Fraser River. It is of the "Frühling" scraper suction type, elevating material by a pair of 16-in. centrifugal pumps through pipes and delivering to hoppers inside the hull. It is a sea-going dredge, of steel construction throughout, and is self-propelled by twin screws. Its length between perpendiculars is 187 ft.; the extreme beam is 34.5 ft., the draft, loaded, about 14 ft., and the hopper capacity at this draft, 800 cu. yd. Its performance from April 1st, 1910, to March 31st, 1911, was as follows:

| | |
|---|---|
| Hours worked | 862.5 |
| Cubic yards excavated | 924 800 |
| Average cubic yards per hour | 1 072 |
| Average cubic yards per day of 9 hours, including all delays | 3 000 |
| Maintenance cost | $37 948.10 |
| Repairs cost | 8 835.58 |
| Total cost | 46 783.68 |
| Cost per cubic yard | 0.0505 |

*Sea-Wall and Pier Construction.*—As stated elsewhere in this paper, there has been very little massive sea-wall construction in the ports of this Coast, San Francisco being the only considerable exception. The earlier type of cross-section adopted there consisted of a loose rock core faced with heavy stone paving. More recently, reinforced concrete on a rubble and pile foundation is being used. There have been some attempts to build vertical concrete walls in Seattle Harbor, but the excessive cost and the injurious effect of the sea-water on the concrete have not led to their repetition. Where the tidal range

is as great as it is at Seattle, a sea wall has to stand above the foundation fully 60 ft., and the cost of a wall built on any adequate plan is almost certain to exceed $300 per lin. ft. This condition has led to various schemes for supporting the land face without the cost of a wall. Creosote or concrete piling, concrete piers, or cylinders supporting a platform back for a distance of from 30 to 60 ft., afford an opportunity to carry the slope up at an angle which can be made stable at moderate expense with brush or rock paving or a combination of both. Much thought is now being given to this problem, and a type of construction will doubtless be evolved which will be a fair compromise between cost and durability.

The same difficulties enter the problem of pier construction. The method heretofore in force along the Coast has been mainly that of wooden piling and timber superstructures—in fact, the simplest form of practical construction. Latterly, there has been a strong wave of sentiment for "permanent" work, which means reinforced concrete substructures and fire-proof superstructures. Conservative considerations, however, are going to place a strict limit on the application of this method, and timber construction, with creosoted piling, where subject to the ravages of the teredo, will continue to be the rule. Any extensive adaptation of the costly masonry construction of European ports is not to be expected.

The serious problem, of course, is that of the substructure. Ordinary piling will not last a year in these waters. Creosoted piling, if of superior quality, is safe for fifteen years; but the lack of stability in very deep water, where depth necessary for draft is augmented by a high tidal range; the great cost of replacement, requiring, as it often does, the removal of shed roofs and the suspension of business; the increased danger from incendiarism, rats, theft, etc., and draft in conflagration, all due to the open work underneath, are very serious drawbacks which go far to offset the advantages of less cost. The most practical compromise with timber construction would seem to be creosoted piling under wharf platforms with protected slopes to bulkheads on line with the shed walls, thus giving solid fills under the sheds. Concrete piling or concrete cylindrical piers, such as are used in the splendid new Government piers at Fort Mason, San Francisco Bay, are, of course, more to be desired for this exterior work. A brief description will be given of two docks, one a fine example of

typical timber construction and the other an original plan of solving the difficulties referred to.

The Grand Trunk Pacific Dock, at the foot of Madison Street, Seattle, is a recent structure. It is 625 ft. long, 128 ft. wide, and is supported entirely on creosoted piles, the length of the bearing piles varying from 55 to 90 ft., with bracing piles as long as 110 ft. The bents are 10 ft. apart, and the piles in the bents are spaced from 6 ft. centers at the inner end to 3 ft. at the center. The capping and floor systems are of very thorough construction, and the dock appears to have thorough stability, notwithstanding the great depth of water in which it stands.

The main shed is 90 ft. wide, with a platform 8 ft. wide on the south side and 16 ft. on the north, the latter carrying a railroad track. There are five adjustable slips on each side and one at the outer end worked by worm gear. The fender piles are of tight-bark fir, and are driven two at every bent and fastened to 12 by 12-in. stringers with $\frac{3}{4}$-in. straps. At the outer end they are spaced 3 ft. apart, and clusters of seven piles are driven at the outer corners. The timber used in construction was 241 775 lin. ft. of creosoted piling, 71 000 ft. B. M. of creosoted bracing, and 1 113 000 ft. B. M. of other lumber. In its finish, offices, equipment, and general lay-out, it is the best example of dock construction on Puget Sound.

The second of the docks selected for a brief description here is the Great Northern Dock, at Vancouver, B. C. It was designed by A. W. Münster, M. Am. Soc. C. E. The pier is 450 ft. long and 293 ft. wide, with a berthing space of 30-ft. depth at low water on each side, and with two sheds, 403 by 102 ft. Between the buildings is a space 41 ft. wide. The distinctive feature of the structure is a cantilever platform supported on cylindrical concrete piers, which themselves rest on a sandstone ledge. These piers are 4.5 ft. in diameter, with a base enlarged to 10 ft. The foundation is carried down into the hardpan or sandstone ledge to a minimum depth of 3 ft. below the bottom of the slip. The piers will have an average height of 52 ft. On top of them will be placed a longitudinal concrete girder, 3 ft. wide and about 7 ft. in depth, which will carry the transverse girders forming the immediate support of the floor slab, which are placed 12.5 ft. center to center. The transverse girders are from 2 to 3 ft. wide, 6 ft. deep, and 51 ft. long. They will project 16.5 ft. beyond the line of

the piers and, acting as a cantilever, will carry corresponding parts of the front platform. The inner end of these girders will rest on a line of 16-in. concrete piles driven to refusal and stayed in position before the rock embankment is placed. The floor slab is to be 7 in. thick. The concrete platform and beams have been designed for a distributed load of 500 lb. per sq. ft. The railroad track running the length of the platform is placed centrally over the longitudinal girders. The reinforced concrete construction supporting the track is proportioned to carry a 100-ton switch engine. Tie-rods encased in concrete will anchor the concrete platform firmly to the embankment.

The warehouse buildings are of wooden construction covered with galvanized iron. The roof is to be carried on trusses spanning the whole width of the building, leaving an unobstructed floor space. The floor inside of the building will be paved with creosoted blocks on a concrete base. The concrete slabs on the outside platform are to be covered with an asphalt wearing surface. The cost of the completed dock and buildings will be approximately $1.50 per sq. ft.

## IV.—Administrative Systems.

*Public Ownership and Control.*—In discussing the different systems of administrative control which obtain in the ports of the Pacific Coast, it is necessary to take cognizance of the present strong trend of public thought in favor of public ownership and control of port facilities. It would be interesting to examine the reasons which underlie this movement, but it must suffice for the present purpose to say that they are essentially the same as those that have substituted the free public highway for the toll road of former times. For the wharf is in reality the transfer point between a free public highway on the land and a free public highway on the water, and there is no more reason why this point of transfer should be made a subject of private monopoly than either highway. The transfer may not indeed be made wholly free, and the user may properly pay the actual cost of use, just as a user of the public highways pays another for hauling himself and goods along it when he does not perform that service himself. Moreover, a public wharf being built and maintained through the agency of only a limited portion of the community actually using it, the cost cannot be equitably charged to that portion alone, as it would be if absolutely free of tolls and maintained

solely by taxation. A strictly free port is not, therefore, one of the things to be expected or desired, and is not likely to be realized except as a result of cut-throat competition between rival ports. The writer will not go further into this extremely important matter of port control than to repeat a summary of the principles involved as stated by him in a recently published article.*

"The true policy for a great port to pursue in these matters would, therefore, seem in the light of present-day advanced practice, to be essentially as follows:

"The wharves with the buildings and appurtenances directly connected therewith should be built and owned by the port itself, and should be operated either directly or by short-term assignments in such way as to eliminate entirely the element of private monopoly, and to bring the cost of service to the lowest point consistent with maintenance, operation, and gradual recoupment of original outlay. Even when this return cannot be fully realized and the utilities have to be supported in part by taxation, public ownership may still be vastly advantageous through indirect benefits, just as are public highways which yield no direct revenue whatever.

"The system of railway tracks serving the wharves should be consolidated in the larger ports, under a single unified management, separate and distinct from the tributary railway systems, except as they form the connecting link between such railways and the wharves. These service tracks may be managed either by a private terminal company, subject to port supervision, or by the port authorities themselves. The latter method has definite advantages.

"So far as a port may directly or indirectly foster industrial development in connection with its own utilities, it should do so upon terms which will attract private capital and insure it a sufficient lease of life to enable it to work out its plans and enjoy the fruition thereof. The case is essentially different from that of public utilities, and so far as a port may be drawn into such enterprises it must necessarily be upon a different basis. There is no question that many industrial enterprises have so close a connection with water and rail transfer facilities as to make them quasi-public enterprises. While they are not of a character which a port will ordinarily take up as an original proposition, they are entitled to every practicable measure of cooperation and assistance which the port may give, and are to be considered as an essential element in its successful development."

In many European ports there is a close approach to this ideal, though with wide variations under different governments and customs.

* *Railway and Marine News*, Seattle, Wash., May 1st, 1912.

In America the ultra-democratic ideal of *laissez faire* and non-interference by Government led to an almost universal custom of private ownership of harbor frontages. Astute business foresight was not slow to appreciate the opportunity thus offered, and the important points of every important harbor, almost in its infancy, became private monopolies. When the railroad came, this evil assumed an aggravated form, and it would be a threadbare story to describe the extensive appropriation of water frontage by the railroads, particularly in the newer sections of the country.

As time has passed and the public has been brought face to face with a situation resulting from its own earlier indifference, a change in sentiment has taken place and is just now in full tide of progress. The people are determined to recover the birthright which they bartered away for a paltry mess of pottage. It is no paltry ransom, however, that they are being compelled to pay. Untold millions are being paid and will continue to be paid for what should never have been parted with at all; but the people are determined, cost what it may, to regain control of their water fronts. Private interests resist—it is the loss of a rich monopoly—but they cannot prevail, and the force of public sentiment should be brought to bear to make the struggle as brief as possible.

*San Francisco.*—Among the ports of the Pacific Coast, San Francisco is the one bright exception in the past to the rule of private ownership. The principle of public ownership and control has, indeed, been adopted in all three of the Coast States; but it has failed utterly in application except in the Port of San Francisco. A significant proof of the overshadowing importance of this port in the past history of the State of California is seen in the fact that early legislation on port matters was directed almost exclusively to San Francisco, and a system of government was established there which was not applied to any other port of the State. The statute which created the Board of State Harbor Commissioners (note, it is a State tribunal, perfectly general in its title) limits its jurisdiction to "possession and control of that portion of the Bay of San Francisco" (description by metes and bounds takes up three pages in the printed statute), extending in general terms from the Federal Reservation (the Presidio) near Golden Gate around into the Bay to the line between San Francisco and San Mateo Counties. Though a State body, its

activities are purely local and pertain exclusively to a portion of the water-front of a single city of the State. Its officers are appointed by the Governor and confirmed by the Senate, and are a regular part of the political machinery of the State. The first Board of Commissioners was appointed in 1863, and the Board has been in existence, therefore, for very nearly half a century.

Whatever may have been the failings of this body—and it has been accused of many things, particularly of being a subservient political organization—the fact that, through all these years, in a State where railroad influence was supreme, it has maintained the integrity of the water-front of San Francisco and has kept it in public control, must stand to its everlasting credit. To-day San Francisco, New Orleans, and Montreal are the only American ports in which the principle of public ownership is practically applied on a large scale, and though the system in force in San Francisco is not as perfect as that in New Orleans, it is a vast improvement over that which prevails generally in the ports of this country.

The vicissitudes of economic progress, however, have at last made the system of State control antiquated, and San Francisco is now ready to forego the pupilage of the State and take her future into her own hands. She wants home rule. She notes with anxious eye the prodigious strides of Los Angeles, San Diego, and particularly the cities across her own Bay. These ports are helping themselves, except that they are receiving from the State grants of tide lands amounting to many thousands of acres. They are organizing on the basis of their own needs. They issue their own bonds. They prepare their own plans. They fight their own battles. They are not tied down to legislative sanction for the measures they desire to adopt, and do not have to go to the electorate of the whole State for financial aid. They may be no longer willing to help pay San Francisco's bills, and it behooves San Francisco to get authority to pay them herself. She is waking up to the situation and is now earnestly agitating for complete home rule of her port. Undoubtedly it will come, and with it a more energetic and efficient working out of her destiny.

The small importance of the east side of the Bay in the early years made it an easy prey to private interests. Although the water-front of Oakland was granted to the town by the State as far back

as 1852, it immediately passed into private hands on a long-term lease, and finally fell into the control of the Southern Pacific, from which it has only recently been wrested by strenuous litigation. The port is fully alive to its opportunities, and the course of development from now on will unquestionably be in the direction of public ownership and control. As yet there is no port organization separate and distinct from the City Government. In time the east-side towns undoubtedly will consolidate, and a comprehensive port organization will be developed. Whether such an organization for the whole of San Francisco Bay will ever be adopted is doubtful. The jealousies of the two sides are too strong to make union practicable at present; but to the onlooker from the outside, a port commission for the whole of San Francisco Bay, with unified development of the entire port, would seem to be the best plan.

*Los Angeles.*—In Los Angeles there is no separate port organization distinct from the City, but the policy of public ownership is making great headway. Probably the bitterest struggle ever waged to rid a port of the incubus of private monopoly of its water-front is that of Los Angeles against the allied Southern Pacific and other interests. Of the final triumph of the people's cause there is no longer any doubt, though the delay and expense of litigation are a severe strain on the patience of the community. The administration of the port is divided on indefinite lines between a board of public works and a board of harbor commissioners. The method, of course, is unbusinesslike and has resulted, as might have been foreseen, in conflicts of authority which have seriously disturbed the orderly procedure of the work of port development. One of the first problems which Los Angeles should solve is the working out of an efficient system of port administration.

*San Diego.*—San Diego furnishes an interesting example of the prevalence of home-rule sentiment in Californian ports. In 1910 the State voted $1 500 000 in bonds for the development of the harbor; but the people preferred home rule, and the Legislature annulled the grant and ceded the tide lands within the city limits to the City on condition that the latter shall expend $1 000 000 in port development along specified lines and within a specified time. There is no separate port organization in San Diego, and the development work is carried out as an adjunct of the City Administration.

*Portland.*—The Oregon system of port management is admittedly not a satisfactory one, and, as exemplified by its application to the principal port of the State, it is in no sense an efficient one. It does not embrace any comprehensive scheme of port development and control, and, until quite recently, it contemplated nothing in the line of public ownership and control of dock facilities; it left the whole matter to private enterprise. The river front was originally deeded to the City, but has passed almost entirely into the hands of private interests—mainly that of the railroads. So strong was the hold of this system that, when the "Port of Portland" was created twenty years ago, its purpose was not at all to provide port facilities, much less acquire or control those in existence, but solely to secure and maintain a 25-ft. channel to the sea. It was simply an ally of the Government in its regular work of channel improvement. Certain specific functions have since been added, such as control of pilotage charges and the building of a floating dry dock; but in its essential purpose it is still an agency for channel improvement only. Its name, therefore, is a misnomer, and, when public sentiment became aroused recently to the necessity for some actual measures in port development, a new body was organized—the Portland Dock Commission—to take up this particular line of work. A bond issue of $2 500 000 was authorized, and plans are actively in progress for the construction of a system of public docks. On the face of it, the whole arrangement appears to be of an unsatisfactory and piecemeal order. Neither the original nor the new commission, nor even both together, has anything like a comprehensive jurisdiction; but their work has to be supplemented by co-operation with the City, and thus there is a sort of three-cornered jurisdiction of the port. It is scarcely to be expected that such a system can be permanently satisfactory. In all probability there will result a consolidated port organization, which will comprehend the present divided jurisdictions and proceed systematically with a unified upbuilding and administration of the port.

*The Washington State Law.*—The State of Washington has recently taken the most advanced position of any of the Pacific Coast States in this important matter of port administration. By Act of March 14th, 1911, it provided a system of comprehensive port development and control under an organization for that exclusive purpose. The organization is styled a Port Commission, and is composed of

three members elected for terms of one, two, and three years, respectively, in the first instance, and one Commissioner each year thereafter for the three-year term. The powers of the Commission are very comprehensive, embracing the whole range of port development and a large measure of port control. Certain powers are still lacking for the legal enforcement of rules, etc., and there is doubt as to the extent of the Commission's power in promoting industrial enterprises. There are, however, certain crude provisions which need modification to make the statute run smoothly; but on the whole it is the most elaborate, comprehensive, and effective measure of the kind ever passed. It will take time for it to gain full recognition, for it strikes at the root of private monopoly in communities where a large element of the so-called "business" interests is immovably committed to such monopoly; but, if it ever has half a chance to demonstrate its efficiency, it will command popular approval. Two districts have already been organized—one in King County, in which Seattle is located, and one in Chehalis County, which embraces Grays Harbor. In the Seattle District the law has been put into effect with great vigor, and a programme of $6 000 000 has been adopted by popular vote.

The development of the Port of Seattle prior to the passage of this law is a typical example of the complete miscarriage of a great purpose. In no State in the Union was a broader view taken of public questions of this character in framing the Constitution than in Washington. It was the purpose of the State to hold the tide lands in perpetuity for the use of the people, and the first Board of Harbor Line Commissioners was in earnest and determined to abide by the purpose of the Constitution. It would have been a great thing for Seattle if it had prevailed; but the time was not ripe. Public sentiment did not support it. It robbed private interests of too many opportunities for speculation. The false cry of business necessity prevailed, and in one way and another the Constitutional injunction was completely nullified, and the tide lands, now worth many millions, passed wholly into private hands at almost nominal rates. Streets were vacated, and even the harbor area, the phantom relic of a beneficent intention, was so tied up to abutting lands as to become a private monopoly. To-day the Port Commission, in trying to recover enough of this wasted heritage to build its first piers, is asked to pay, in some instances, as high as $86 000 per acre.

*British Columbian Ports.*—The British Columbian ports, particularly Vancouver, are wholly private-ownership ports, and the water-front development is almost exclusively in the hands of the railroads. It is a striking contrast to the great Canadian port of Montreal, which is one of the most progressive public-ownership ports in the world. Vancouver is passing through the boom experience of most new localities in the West, and is willing to make almost any concession to private interests for what promises most for the immediate present. Not until after the present period of expansion has passed, and public thought, now absorbed in speculation activities, has time to take stock of the situation, is it likely that the problems of port control will be given very serious consideration.

*Port Charges.*—The diversity of administrative method among the Coast ports is particularly manifest in port charges. The widest difference prevails, and in only one port is there a definite and uniform system. San Francisco has a well-defined schedule of charges, and, whether the best adapted to the purpose or not, it is carefully worked out and serves its purpose very well. In most other ports of the Coast, rates are a matter of private arrangement, although in each there is generally a voluntary agreement among shippers as to what they shall be. They vary greatly, and even in the same port different rates are often applied according to the exigencies of the case. Thus, in Seattle, the basing rate on foreign cargoes is 25 cents per ton, and on coast and local cargoes 50 cents per ton. In San Francisco the whole matter is strictly regulated by a public body, and there is complete uniformity and absence of discrimination. Heretofore in Seattle there has been no such regulation except the ineffectual regulation of the State Commission, and there are frequent complaints of discrimination and irregularity. The two systems, moreover, are essentially different. In San Francisco there is a substantial dockage charge against the vessel; in Seattle there is no such charge, the entire charge being against the cargo. It is this custom which has given Seattle the reputation of being a "free port", but the freedom refers only to the vessel itself. The system is not an equitable one, and will have to be changed as soon as an agreement among the Sound ports can be reached. The San Francisco system is the more rational one in this respect. It comprises three fundamental charges, which have been defined officially as follows:

Dockage.—The charge made for vessels occupying berths at the wharves or moored in any slip or channel.

Tolls.—The charge made for merchandise passing over State premises.

Wharfage.—The charge made for leaving merchandise on State premises longer than the time specified in the rules.

In the Puget Sound ports there are no dockage charges unless a vessel is lying alongside a dock unengaged. The "handling" of the cargo corresponds to "tolls" in San Francisco, though it is less definite in its application and sometimes has no application at all.

Although the San Francisco system appeals to the layman as the more rational and just, the ship operator is positive in his preference for the Puget Sound system (if it can be called such) and holds that it is decidedly the cheaper port. As far as the vessel is concerned, this is true, but there is no great difference in amount where the total cost to ship and cargo is considered. Labor conditions in San Francisco make stevedoring higher than on Puget Sound, but this is a matter entirely apart from the port regulations in themselves. Labor unions may at any time force wages in other ports to the San Francisco scale, and, therefore, a correct comparison of systems should assume uniformity of wages.

In Los Angeles the charges are classified under the heads of dockage handling, and wharfage, "handling" corresponding to "tolls" in the San Francisco schedule. The rates in San Francisco are fixed by the Board of State Harbor Commissioners, supplemented by several statutory enactments. In Los Angeles they are fixed by the Board of Harbor Commissioners, a branch of the City Government. The City charter gives this Board the same legal powers which the State Board enjoys in San Francisco in regard to the enforcement of its rates and regulations, and gives it the power to punish violations thereof. In San Diego there appears as yet to be no system of local public control of rates, all the docks being in the hands of private interests. As soon as the new municipal docks are completed, the control of rates will be reduced to a system.

In Portland, as in San Francisco, pilotage is compulsory, and is an important item of the vessel's expense while in port. The wharves being all private property, there is no public control of rates, and the

charges of various kinds are determined largely by the individual wharf owners, although, of course, there is general conformity to an agreed schedule. The new Dock Commission, by the erection of its own wharves, will naturally assume control of future charges.

In Seattle the newly created Port Commission has the power to fix rates, but has exercised that power for the present only as a matter of form to comply with certain requirements of the statute. Prior to the actual completion of the docks which it contemplates building, it will adopt a thoroughly considered rate schedule. Under the present law it has no legal machinery with which to enforce compliance with its rules, but this defect will doubtless be corrected by the next Legislature.

In Tacoma and other Sound ports, practically the same system and schedule of charges prevail as at Seattle, but it may be expected that, in the near future, an effort will be made to revise the whole system through some mutual agreement.

The British Columbian ports being still almost exclusively under railroad control and ownership, as far as port facilities are concerned, the rates are privately controlled, and the charges are absorbed largely by the railroads.

*Co-operation among Ports.*—The writer's study of this question has led him to believe that important results might follow a duly organized conference among the recognized authorities of the various ports on the Coast with a view to evolving a uniform system of port administration and of port charges.

## V.—Plans for the Future.

Let us now take a brief survey of the ports of the Coast from the viewpoint of their plans for the future. In the first part of this paper it was stated that the Coast is putting its house in order for the reception of the trade which will come from the opening of the Panama Canal. It is a safe assumption that nine-tenths of the funds provided in the past three years, or that will be provided in the next three, for the development of the Coast ports, have been secured through the argument that they are necessary for the above purpose. Ambitious plans have been prepared by recognized experts looking to a future a hundred years ahead and involving expenditures which can only be guessed at. To a great extent these plans will slumber indefinitely, because of

TABLE 6.—COMPARATIVE COSTS TO SHIP AND CARGO IN PACIFIC COAST PORTS.

| | SAN DIEGO. | | LOS ANGELES. | | SAN FRANCISCO. | | PORTLAND. | | PUGET SOUND. | | VANCOUVER, B. C. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rate. | Amt. | Rate | Amt. | Rate. | Amt. | Rate | Amt. | Rate | Amt. | Rate. | Amt. |
| Pilotage (in) | $3 per ft. draft ..... 3 cents per ton ..... | $270 | $1 per ft. draft ..... 1 cent per ton ..... | $90 | $3 per ft. draft ..... 3 cents per ton ..... | $270.00 | $4.50 per ft. draft ..... 3 cents per ton ..... | $315 | $125 to $175 ..... | $150 | $1 per ft. draft ..... 1 cent per ton ..... | 890 |
| Water, survey and misc. (estimated) | ..... | 50 | ..... | 50 | ..... | 50.00 | ..... | 50 | ..... | 50 | ..... | 50 |
| Dockage, per day | $2 plus 3/8 cent for each ton over 200 | 285 | For ship over 1 200 tons. | $14.75 177 | Discharging: $4 plus 3/8 for each ton over 200. Loading: 1/2 of above | 427.50 | None ..... | 0 | None ..... | 0 | None ..... | 0 |
| Stevedoring, per ton | 40 cents. | 9 600 | 40 cents. | 9 600 | 40 cents. | 9 600.00 | 40 cents. | 9 600 | 40 cents. | 9 600 | 40 cents. | 9 600 |
| Handling, per ton | Included in "wharfage" | ..... | 41.8 cents (av.) | 10 032 | 25 cents. | 6 000.00 | Included in "wharfage" | ..... | Included in "wharfage" | ..... | Included in "wharfage." | ..... |
| Dock rental, per linear ft. per month | 0 | ..... | 0 | ..... | 45 cents. | 225.00 | ..... | ..... | 0 | ..... | 0 | ..... |
| Wharfage, per linear ft. per month | 50 cents | 12 000 | 6 1/2 cents (av.) | 1 560 | 5 cents (24 hrs.) | 1 200 00 | 50 cents | 12 000 | 50 cents (120 hrs.) | 12 000 | 50 cents. | 12 000 |
| Wharf storage, per linear ft. per month | ..... | ..... | ..... | ..... | 5 cents (48 hrs.) | ..... | ..... | ..... | 25 cents per ton per mo. or fmc. mo | 0 | ..... | ..... |
| Pilotage (out) | Same as "in" | 270 | Same as "in" | 90 | Same as "in" | 270 00 | Same as "in" | 315 | Included in charge for "in" pilotage | 0 | Same as "in" | 90 |
| | ..... | $22 475 | ..... | $21 599 | ..... | $18 042 50 | ..... | $22 280 | ..... | $21 800 | ..... | $21 830 |
| Cost paid by ship | ..... | $875 | ..... | $407 | ..... | $1 242.00 | ..... | $ 680 | ..... | $200 | ..... | $230 |
| Cost paid by cargo | ..... | 21 600 | ..... | 21 192 | ..... | 16 800.50 | ..... | 21 600 | ..... | 21 600 | ..... | 21 600 |

This table is the result of a comparative study of the rates in the different ports with a view of determining the relative tax on commerce in each. In order to arrive at a condensed approximation of the cost of terminal charges and a comparison of the principal Pacific Coast ports, a purely hypothetic case has been assumed of a 6 000 net ton register ship, 30-ft. draft, discharging and loading cargoes of 12 000 tons of miscellaneous freight, the ship remaining in port 12 days. It is admitted that the assumption is not typical of ordinary occurrences, but it is apparent that, because of the complex and diversified tariffs, as well as lack of uniformity in freight staples, it is well-nigh impossible to obtain averages except through an assumption that is somewhat strained. The cost of stevedoring has been taken at the uniform rate of 40 cents per short ton at all the ports. This is not strictly true, but the labor unions may be relied on to equalize the cost by dictating the labor wage and the length of a day's work. Small miscellaneous items like water, etc., are insignificant, and have been lumped in the table at $50 per voyage. The charge for handling is a variable sum. The attempt has been made to arrive at an equitable average for each port. The dock rental, in San Francisco, for lines having regular assignment, is 45 cents per month per linear foot of dock rental. A 500-ft. space will amount to $226 per month. A monthly sailing for the case docketer will make the rental $225 per voyage.

their very excess over any actual requirement; but nevertheless there will be an immense stride forward in definite development. How far it will extend in the near future will depend on the progress made before the tide of popular enthusiasm begins to ebb, as it may be expected to do within a few years after the opening of the Canal, and the shrewd promoters of port development and no less shrewd port engineering experts will doubtless make the most of the present opportunity and ride on the crest of the flood wave to a point which the normal depth of water would not permit them to reach.

*San Francisco Bay.*—San Francisco has a fund of $10 000 000 for port improvement, embracing sea-wall and dock construction and the acquisition of 64 blocks of submerged tide lands. A considerable portion of this sum will probably have to be used in replacing defective structures, but it is already decided to build twelve additional wharves of dimensions varying from 600 to 850 ft. in length by 140 to 200 ft. in width. Six additional ferry slips are to be provided, and the two sections of the belt railway are to be connected across Market Street. The approaching Exposition will doubtless stimulate to still greater exertion, particularly if San Francisco secures home rule in the management of her port.

Across the Bay, the City of Oakland has voted $2 503 000 in bonds, and is actively at work in developing her west water-front and her important interior harbor. Her west front development, or the Key Route Basin, is a promising scheme, involving the filling in of 400 acres of land out to the bulkhead line between the Oakland and Key Route Moles, and wharfing out beyond this, still between the moles, to the pier-head line, in such a way as to form an interior basin with numerous slips and quays.

The plans for the interior harbor are scarcely less ambitious, while Alameda, Berkeley, and Richmond have their own projects of development. These have not yet taken form, however, in actually adopted plans or funds for carrying them out.

*Los Angeles.*—While Los Angeles has fought and is still fighting an heroic battle for the right to build and control a port of her own, she has as yet made only a small expenditure on her own account. She has, however, voted $3 000 000 in bonds and has committed herself to an expenditure of $7 000 000 more. She has had various studies made for the future development of the port, and E. P. Goodrich, M. Am.

Soc. C. E., has presented plans both for the outer and inner harbor which, if correctly reported by the press, are better fitted for a population like that of New York City than anything which even so thriving a city as Los Angeles has any right to expect in the near future. Fortunately, those dazzling schemes are harmless, and doubtless do good by broadening the public vision to a larger horizon.

The Goodrich studies provide an outer harbor in front of Terminal Island protected by a 20 000-ft. extension of the breakwater, and furnishing ten long piers, 500 ft. wide, with intervening slips 400 ft. wide. The inner harbor studies are more immediately practical, though scarcely less ambitious; but, as they involve several alternative plans and have received no official action, it is scarcely worth while to discuss them here. It is enough to add that the actual realization of this plan for 82 miles of developed water-frontage will cost from $75 000 000 to $100 000 000.

According to the latest report of the U. S. Chief of Engineers, the City "is preparing to undertake immediately the improvement of 79 acres on the westerly side of the entrance channel * * * rendering available about 9 100 feet of deep-water frontage." This is in the outer harbor.

*San Diego.*—In San Diego no comprehensive scheme of development has yet been prepared, but the City has voted the sum of $1 000 000 for new docks and for sea-wall construction. The length of berthing space to be provided with this fund is 1 600 ft., and the length of the sea wall is to be 2 500 ft. This will make possible the reclamation of 50 acres of tide flats. No definite steps have as yet been adopted for a terminal belt railway. It is stated that the City intends to follow up its present plans with a $3 000 000 bond issue. Perhaps most important, as bearing on the future of the port, is the project, said to be in contemplation, of building a railroad directly east to Yuma.

*Portland.*—Portland, like San Francisco, is pursuing the sane course of "procuring her cloth before cutting out her garments." In 1910 a Commission of Public Docks was created by City Charter amendment, and the sum of $2 500 000 was voted for the construction of such docks as might be needed in the near future. This Commission employed a board of experts from New York City, consisting of E. P. Goodrich, M. Am. Soc. C. E.; W. J. Barney, Jun. Am. Soc. C. E., and Charles W. Staniford, M. Am. Soc. C. E. A complete de-

tailed plan has been prepared by the Board and has just been made public. Those features of the plan which are proposed for immediate adoption consist of two combination docks, sheds, and warehouses, one on each side of the river, a coal dock, a motor-boat landing, fireboat station, etc.

The West Side improvement will consist of a quay dock, 1 075 ft. long and 100 ft. wide, in the central section of the harbor below the city bridges. For two-thirds of its length it will be a single-level structure, and the rest two-level, the upper being at Elevation 32 and the lower at 18 ft. above low water. The dock will be provided with adjustable slips, escalators, and elevators, and will have space for storing 10 000 tons of freight. A six-story reinforced concrete warehouse provided with full equipment for handling goods will be erected in the rear of the dock. Its capacity will be about 40 000 tons. Three additional warehouses are planned as soon as funds are available. Dock autos will be the main reliance for handling freight.

The East Side improvement, conveniently located for the transaction of business, consists of a two-story quay structure, 500 ft. long by 100 ft. wide, capable of storing 6 000 tons on each level. A one-story reinforced concrete warehouse will be provided with a foundation for five additional stories. All structures in both improvements are to be of steel and concrete, and fire-proof throughout.

In addition to these improvements for immediate adoption, the plan of the Consulting Board provides for future development on the two sides of the river, 7 000 ft. of quay construction, pier and slip development affording 21 200 ft. of berthing space with piers 300 ft. wide, together with the necessary warehouses and other accessories. A large coal-handling plant, freight-assemblage and storage yard with a capacity of 1 500 cars, and a public belt line serving all the docks, are also to be provided. The total development gives more than 6 miles of berthing space, of which only about 1 750 ft. are as yet provided for. As to this initial programme, it is understood that it is acceptable to the Dock Commission, and that steps will be taken immediately to carry it into effect. In connection with the Dock Commission projects, reference may again be made to the joint projects of the Government and the Port of Portland Commission to secure a 30-ft. channel to the sea.

*Puget Sound and Grays Harbor.*—North of the Columbia River, port-development work will doubtless always be associated with the name of Virgil G. Bogue, M. Am. Soc. C. E. Pursuant to a charter amendment of the City of Seattle, adopted March 8th, 1910, a Civic Plans Commission was created for the purpose of forming a plan for the future development of that city. This Commission employed Mr. Bogue as its Engineer, and his very elaborate report, submitted August 24th, 1911, includes a complete scheme of development of Seattle's harbor. Following immediately on the submission of this report came the creation of the Port Commission of Seattle, specifically charged with the duty, among others, of preparing a "comprehensive scheme" of port development. While Mr. Bogue's plans as a whole have not been adopted by a vote of the people, their essential harbor features will be given close study in the preparation of any plans that the Port Commission may adopt. Mr. Bogue, after the completion of his Seattle work, made a similar study for Tacoma and also for Grays Harbor, and he is now engaged on a plan for Prince Rupert. As already stated, whatever action may be taken as to the immediate adoption of his work in these ports, it is certain to have a profound influence on their future development.

The Seattle plan embraces elaborate suggestions for every part of the harbor, with especial emphasis laid on the Harbor Island and Smith's Cove sections. The mosquito fleet and industrial features of the inner harbor are likewise fully elaborated. No effort was made to form an estimate of costs, for the plan is one for long-continued development; but it certainly represents an outlay of not less than $25 000 000.

The Port Commission has definitely adopted an initial programme involving an expenditure of $6 000 000. This includes a slip with two wharves on the east side of East Waterway, giving berthing space for four large ships; a solid filled pier on the central water-front, with an 1 100-ft. berthing space of deep-sea depth, and a floating landing stage for small boats with 800 ft. of landing space, and also a large fruit cold-storage plant; a lumber, coal, grain, and general transhipment dock at Smith's Cove; a small dock for general use on Salmon Bay; and a new ferry across Lake Washington. The Port Commission is taking initial steps looking to the establishment of a terminal railway system for the port.

In addition to the Commission's original programme, there is being considered, at the earnest request of certain business interests, a very ambitious project for Harbor Island, patterned after the Bush Terminals of New York. The pier development proposed comprises six new piers with an aggregate berthing space of 16 800 lin. ft., or enough for the simultaneous berthing of 42 ships of an average length of 400 ft. Back of the piers is to be an extensive industrial development. The whole project is to be a co-operative one between the Port District and a private terminal company.

It is conservative to state that expenditures of all classes—Federal, State, County, City, Port District, and private—actually authorized or in definite contemplation, for the development of Seattle Harbor, aggregate approximately $20 000 000.

The study made by Mr. Bogue of the possibilities of Tacoma Harbor may best be told in his own words, as summarized in his report on Grays Harbor:

"At Tacoma, a great movement is on foot to keep the city well to the fore in all port extension matters. The plans contemplate a canal system with an aggregate length of 6 miles, to say nothing of spurs and laterals which may be built in future years in connection with large industrial enterprises. The cost of this canal system is estimated at about $4 000 000. It will develop a vast area of tideflats and present unexcelled opportunities for industrial development with convenient access from both sea and land. Beside the canal system a number of waterways are to be built and various slips and piers which will provide the best accommodations for vessels engaged in ordinary commerce. When these improvements shall have been made, the wharf frontage of Tacoma between Point Defiance and Brown's Point will aggregate 42.6 miles, all of which is well protected and easy of ingress or egress."

Olympia, Everett, and Bellingham are not as yet taking positive action in the development of their ports, but they will probably do so in the near future.

*Grays Harbor.*—The Port Commission of Grays Harbor, through Mr. Bogue, has prepared an elaborate scheme of development, but the report does not furnish an estimate of its probable cost, and no provision is yet made for carrying it into effect.

*Vancouver, B. C.*—As already stated, no comprehensive scheme of development of this port has been adopted. Special studies have been

and are being made of different parts of the harbor, and there are rumors of gigantic development plans by private interests. The Great Northern Railway has a fine new pier under construction, and other private improvements are in progress; but there is as yet no general plan, no distinctive scheme of port administration, and no provision of public funds.

The conformation of the harbor and the handicap of tidal fluctuation and currents have suggested an improvement which, though costly, would seem to possess great merit. That is to place a lock and dam across the throat of the harbor at the second Narrows, thus holding the upper part of the Inlet at high tide and making it a fixed-level fresh-water harbor. This would restrict the tidal area to one-third its present extent and would reduce tidal currents in the lower harbor so much as greatly to improve conditions there. It would seem on the face of it that this would be an improvement of great importance to the future of the port.

*New Westminster.*—The fresh-water port of New Westminster is taking active steps in harbor development. It has recently expended $15 000 on the study of a plan and its presentation, and is about to put into effect the one prepared for it by A. O. Powell, M. Am. Soc. C. E. It comprises wide marginal streets, routes for railways, the extension of the city quay, and a long waterway in a slough parallel to the river, from which the river is to be excluded at the upper end. A succession of parallel slips, oblique to the axis of the waterway, will develop a berthing space of 7½ miles.

*Victoria.*—Even that sometime staid and delightful provincial town of Victoria, more distinctly British than any other port of the Pacific, has become infected with the Panama *bacillus,* and is cogitating what it may do to be prepared for the changes which it has been told are about to ensue. No definite plans have as yet been evolved, but among the tentative suggestions are an outer harbor to be protected by a breakwater in front of the present entrance to the inner harbor, and also a development in Oak Bay on the opposite side of the town fronting to the eastward.

*Prince Rupert.*—Studies for the Port of Prince Rupert are now in progress under the direction of Mr. Bogue, but are not yet far enough along for incorporation in this paper. A suggestion that has been made of possible future development in this port, however, may be

properly mentioned. Prince Rupert City is on an elliptically shaped island about 6 miles long north to south by 4 miles east and west. The "lakes" which separate the island from the mainland in the rear have an area north of the railroad crossing of about 40 sq. miles. It is not unlikely that the north and south passages will be dammed off and provided with locks, thus converting the lakes into a tideless, fresh-water harbor just at the level of high tide. While this development is still some distance off, it has such great advantages, in view of the extreme tidal fluctuation in Prince Rupert Harbor, that it will probably be realized eventually.

*Outlay on Pacific Coast Ports.*—From the statistics of obligations actually assumed to date, and by the aid of the most reliable forecasts obtainable of port planning for the near future, it will be a conservative estimate to place the cost of port development along the Coast during the next five years at $50 000 000.

## VI.—Influence of the Panama Canal.

The writer will close with a brief statement of the influence ot the Panama Canal on the commerce of the Pacific Coast. The aggregate effect will be a summation of the following:

(1) Effect on consumption and production among the existing population;
(2) Effect on consumption and production through increase of population—chiefly immigration;
(3) Effect on rail commerce between the Pacific and Atlantic Coasts;
(4) Effect on industrial development;
(5) Effect on Oriental traffic to the east coast of America now transhipped to rail at Pacific Coast Ports;
(6) Adverse effect of Canal tolls.

*Consumption and Production.*—Under the first heading, it may be assumed that there will be some increase of consumption due to a reduction of prices resulting from lower freight rates *via* the Canal. For example, anthracite coal may possibly find considerable use along the northern coast, where now it finds very little, if any at all. As to production, the effect ought to be extensive and immediate on lumber products, for the Canal will open to Coast lumber the market of both shores of the Atlantic, and the production can be instantly increased

to any desired extent by putting existing mills now closed into operation or speeding up others to their full capacity. In the matter of fruit and cereal products, no radical effect on production should be expected as an immediate result of opening the Canal. The conditions are not the same as with lumber, and any material increase of production must await an increase of population and general development.

*Immigration.*—This consideration brings up the second heading specified—the influence of the Canal on the increase of population on the Pacific Coast. It is an influence which, in the long run, may prove the most important of all; for it is not so much additional port facilities that are needed to develop a country as increased numbers of those who do the work of development. Many other factors, of course, contribute; but in a new country increase of population is the main thing, and this must come in large part through accessions from the outside. There is a general consensus of opinion that the opening of the Canal will have more immediate effect on immigration than on any other class of traffic. In this fact lies a great hope and a great peril for the Coast. What kind of immigrants will be brought here? What reception will they meet? Will they prove a blessing or a curse to our communities? The writer will consider these matters no further than to quote a paragraph from a bulletin recently published by the Seattle Port Commission:

"In this connection the commission may be justified in digressing so far as to observe that the real preparation for this influx of immigration rests with the people of the State rather than with the Port Commission or the Government. If intelligent and organized effort is made through agents in Europe to secure a good quality of immigrants, and if similar effort is made here to start them in their new career without too much hindrance and discouragement and without being victimized by those whose only desire is to fleece them of their meager belongings and leave them stranded in a country where the problems of successful agriculture are so different from what they are accustomed to, this immigration may be of inestimable value to the State and indirectly to its metropolis and chief port. But if this matter is allowed to drift along without organization or sympathetic effort in aid of the new arrival, the result may be to crowd this port with an indigent population and to justify the effort which is said to be already under way here to resist the whole immigration movement."

*Diversion of Rail Traffic.*—In reference to the third consideration, a degree of uncertainty exists which completely nonplusses the ablest

traffic authorities of the country. The rail traffic between the Pacific Coast and points far enough east to be affected materially by the Canal is smaller than is popularly supposed. A high railroad authority has estimated that not more than 600 000 tons of traffic goes to the Northwest Coast from east of "Missouri River common points", and that only about 20% of this originates east of Buffalo or Pittsburgh where the influence of the Canal would be effective. On traffic from the Great Lakes and from the Mississippi, Ohio, and Missouri Basins, it is not likely that the Canal will have much effect. The railroads will hold it, except for the possibility that it may cease to originate in those sections. All but about 7½% of this traffic, it has been estimated, might originate on the Atlantic and Gulf Coasts, where it would fall directly within the Canal influence. Is it not likely that the ultimate result of the Canal will be to transfer to the Atlantic Coast much of the Pacific Coast traffic which now originates in the central sections, thus cutting off from both the railroads and the producer of the Central West an important business? And is it not a perception of this probable result which accounts for the lukewarmness, if not active opposition, of certain sections of the country to free tolls for coastwise trade through the Canal? In any event, it seems to be reasonably certain that the Canal (particularly with free tolls) will transfer from rail to ship a large part of the traffic which now crosses the country to the westward by rail. This will operate to increase the business of ports on both coasts and of the railroads from the coast inland for uncertain distances.

As to east-bound traffic originating on the Coast, lumber shipments will increase very largely, but rather through the opening of new markets than the diversion of existing rail shipments. The present eastern market for Coast lumber is mainly in the tramontane region eastward as far as the Mississippi. The market farther east cannot stand the heavy freight charge, except for shingles and the finer grades of lumber. The market of the Central West will continue to get its supply by rail, and only consignments farther east are likely to be diverted to the water route.

With fruit products of all kinds along the Coast, there is every reason to believe that the Canal will effect a marked change in the method of shipment. Refrigerator ships will carry this product to both shores of the Atlantic in better condition and at cheaper rates

than can be done under present conditions. It is estimated that within 10 years the fruit shipments from Central Washington and Oregon will approach 100 000 carloads, while the shipment of all classes of fruit from California will exceed that figure. The problem of handling those prodigious quantities by rail in the short periods and over the long distances necessary may prove an impossible one; and the water route will come in as a great relief in addition to its normal advantages. It seems to be one of the certainties of the near future that cold-storage plants of immense capacity will be built in all the principal ports in order that the fruit crop can be stored in part, awaiting shipment.

In regard to wheat and other grain, and fish products, the Canal will not make much change, because these products already go largely by water; but considerable change in the method of water shipment is likely to result. Wheat, for example, is now shipped mainly in sacks in order to avoid the alleged danger of heating if shipped in bulk on the long voyages *via* the Horn, Good Hope, or Suez. The shorter voyage *via* Panama will obviate this difficulty, and we may expect to see elevators in greater numbers provided in our ports, as they are on the Great Lakes, at Montreal, and in other Eastern ports.

*Industrial Development.*—It is a much disputed question as to what the effect the Canal will have in promoting industrial development on the Coast, particularly manufactures. Some hold that the lower freight cost will bring raw materials here at rates which will make manufacturing practicable where it is not at present. On the other hand, it is argued that the lower rates will bring manufactured products from the East more cheaply than at present, and that this will offset the tendency just noted. Where the balance of these conflicting forces will fall is wholly problematical, but it is certain, from the uniform experience of the older sections of the country, that increasing growth in population and wealth of itself will bring increased development of manufactures. It will become a part of the development of every port, and will operate to increase its business.

*Oriental Traffic.*—As to Oriental traffic transhipped to or from Atlantic or Gulf points, it is clear that the effect of the Canal must be to draw it away from Pacific Coast ports. It will not draw it away altogether, because, with certain commodities, like silk, of high value in proportion to freight charge, the interest on purchase cost may amount to more, through the longer time required to receive the goods *via* the

Canal, than the saving in freight. Most of the manufacturers consulted are agreed that silk shipments will continue to go by rail. With other articles, however, such as hemp bound East and cotton bound West, it would seem that, if through lines are established direct to the Orient, *via* Panama, they must absorb this class of traffic.

*Canal Tolls.*—It is a matter of profound satisfaction to be able to state in this discussion of the ports of the Pacific Coast that a question vital to their welfare and one but yesterday of doubtful issue has been settled and settled right. Our coastwise trade will pass through the Canal without paying any toll. The great principle of the free public highway, and of the free use of public improvements of rivers and harbors, has triumphed over the narrow vision and selfish interest that threatened to defeat it. It is one of the greatest victories of an enlightened national citizenship, which illumines the record of this generation.

The victory, however, great as it is, is not as great as it should be. The Canal should be free to all commerce. The highway toll system on this great thoroughfare should be abolished for all nations and forever. The same system on the public roads became its own executioner, because it defeated its own end. It prevented the use for which the road was built, and while it was an improvement on no road at all, it never performed its full service. So likewise, tolls on commerce through the Panama Canal will restrict the rightful use of that great work. This is a demonstrable certainty. Take a table of distances and look up, for example, the routes from New York to Valparaiso *via* Panama and Magellan. The Panama route is 3 500 nautical miles shorter. Yet it is a fact that the delay in passing the Canal plus the toll cost at a dollar a ton commuted into cost of running the vessel will make it cheaper for large fast vessels to take the longer route. To vessels between Valparaiso and European ports, the disparity against the Canal route will be still greater, and, of course, the same principle applies in varying degrees to all routes. Tolls will inevitably restrict the use of the Canal, and thus deprive the United States and the rest of the world of its full benefit.

It is one of the most powerful illusions that public thought is subject to, that a work like this, in order to justify itself, must be made to pay its own cost in direct revenue. It is easy to overlook the fact that every dollar collected in this way has to be paid by the people in

some other form. At the very best, it is taking out of one pocket to put into another, and meanwhile the utility of the work is being curtailed by restriction of use. Happily the true principle has been grasped by our legislators and applied to the Canal, as far as our own trade is concerned, and that is the utmost which it was in their present power to do. It is only just that foreign nations which have borne no portion of the cost of the Canal should pay something for its use. No one can question the correctness of that position, but this end should be attained by payment for this use, without imposing a toll, by the discovery of some method which will not restrict the use of the Canal. Is such an achievement possible? The writer believes that it is.

It can come, of course, only through international agreement; but it is conceivably practical to form a convention by which each nation shall pay into the Treasury of the United States a proportion of the rightful charge based on the actual use of the Canal by its own subjects, or under its own flag, or on the tonnage to and from its own ports. The charge would be computed on cost of maintenance and operation and such an additional sum annually as would retire the indebtedness within a determinate period. The question is surely worthy of highest consideration, and few subjects more vital to the interests of the world at large could engage the attention of the Third Hague Conference in 1915 than this of mutual co-operation to make the greatest public work of the ages free to all users. Let the police jurisdiction, direct control and operation, and questions of use in time of war be left to the United States; but otherwise let it be free. As the writer has elsewhere said, a "way must be found for making Panama and Suez as free to the world's commerce as if Nature herself had excavated their channels—as free as are the Straits of Gibraltar and Magellan."

# DISCUSSION

L. J. Le Conte, M. Am. Soc. C. E. (by letter).—On page 180 the authors speak in glowing terms of the future possibilities of the Lake Washington Ship Canal scheme, now well under way. As a matter of historical interest, it may be stated that, in October, 1871, the late Gen. B. S. Alexander, accompanied by Lieut. (now Col.) Thomas H. Handbury, M. Am. Soc. C. E. (both of the Corps of Engineers, U. S. A.), and the writer, as Assistant Engineer, went to Puget Sound with the view of making extensive "current observations" for the purpose of determining the practicability of harbor defense by torpedoes. While on this mission, Mr. Briar Brown and Dr. Whitworth, two estimable citizens of Seattle, took the party to the proposed ship canal site, and explained the scheme. Orders were received to make the survey, and called for plans, estimates of quantities, and probable cost of making a ship canal, Mr. Le Conte.

"with the view of ascertaining the adaptability of this lake for a naval depot, and the proper route for a ship canal to connect it with Admiralty Inlet, and the cost of such canal.*"

The field work was done by Lieut. Handbury and the writer. The report of the results of this survey will not be found in the River and Harbor Index, because the expenses came out of "Surveys for Military Defense"; consequently, it will appear only among the Senate Executive Documents for the fiscal year ending June 30th, 1872.

At the time this survey was made, it was claimed that the main object of the fresh-water depot was to enable the naval fleet to go up into Lake Washington, and, while taking on stores and supplies, all barnacles, sea-grasses, etc., befouling their bottoms would naturally drop off, leaving them clean when they proceeded to sea. In ordinary cases, of course, ships would have to go into dry dock to have their bottoms cleaned. For large vessels, this would be a matter of $2 000 per day in dock expenses, hence the great saving to be naturally expected. The writer has no doubt whatever of the great future possibilities of the Lake Washington Ship Canal, and will watch its growth in usefulness with interest.

Speaking of the Sound waters in general, the writer was greatly impressed by the bold shores everywhere. In fact, a 3 000-ton ship can go up to the shore, make fast to the trees, and lay there as long as necessary. This same feature was also noted in Lake Washington, and the writer is firmly of the opinion that it is due to vertical stratification; thus, whenever one stratum drops off, it always leaves a new vertical face standing. This natural feature makes trouble for

* Report, Chief of Engineers, U. S. A., 1872, p. 26.

Mr. Le Conte.

the commercial wharves along the shore, but, nevertheless, it has its advantages in some cases.

The removal of Blossom Rock, in San Francisco Harbor, was a most interesting piece of work, and the fact that it ended disastrously was due, as usual, to unexpected contingencies. The writer had the pleasure of visiting the work several times during its progress, and just after the blast, in April, 1870, was told by the late Col. A. W. von Schmidt, the contractor, that he was compelled to set it off some time before he really intended, because of the exceedingly shaky condition of the rocky shell overhead, which had to be propped up with timbers. The tremor due to the working of the hoisting engine at the main shaft would start up leaks everywhere, and he was dreadfully afraid of a general collapse; hence the blast was premature. The subsequent quantity of dredging and scraping necessary to get the required depth of 24 ft. at low water ate up all the profits on the contract.

The draft of vessels entering the harbor gradually increased to 28 ft., and in November, 1902, a second contract was let for increasing the depth over the rock to 30 ft. at low water. The extra 6 ft. to be removed being largely loose broken stone, the contractor resorted to surface blasting, and excavating with a clam-shell dredge and a 10-ton bucket of the grapple type with long lever arms. The results were highly satisfactory.

The same system and dredge were also used in the removal of Shag Rock No. 2, and the results were equally satisfactory. The whole secret of success in surface blasts lies in the use of small charges, exclusively. The writer had local charge of the removal of Rincon Rock, in San Francisco Harbor, and the contractor engineer, Mr. Albert Boschke, made the great mistake of using 40-lb. charges for surface blasting before dredging the broken rock. Such large blasts simply expend their force in making a fine fountain, and the mechanical effect on the bottom, where it is needed, is practically nothing.

The quantity of powder required for each blast is that which will just begin to make a fountain. In most cases this is about 6 lb. of, say, 90% nitro-gelatine. These small blasts, judiciously distributed and followed immediately by clam-shell dredging, are by far the cheapest and most effective, where applicable.

A few remarks about the great jetty at the mouth of the Columbia River may not be out of place. The prodigious movement of sand mentioned in the early reports on this work proved to be a myth, and later experience showed that the sand simply traveled in an orbit of limited diameters. When the Point Adams Jetty was well extended, the sand movement practically disappeared, because it was "bottled-up." The depth of 31 ft. was obtained over the bar, and everybody rejoiced. Peacock Spit, on the north side, next to Cape Disappoint-

ment, was practically the natural north jetty. Unfortunately, Peacock Spit was cut away by subsequent heavy storms and strong currents, and as a result the bar shoaled up to its original depth of 21 ft. at low water. It is very evident that the only thing to do is to build another jetty from Cape Disappointment out along the crest of Peacock Spit, and thus maintain the spit and hold the tidal currents up to their work along and against the south jetty. The writer is of the opinion that a 31-ft. channel cannot be maintained unless Peacock Spit is fixed on the north side. Mr. Le Conte.

Dredging has grown to be a most important adjunct to every type of harbor work. The great advances made in machinery have cheapened the cost of dredging to such an extent that all schemes for proposed harbor work are now materially affected thereby. It may be stated that the day for extending jetties out into deep water in order to maintain the depth on the bar is gone forever. The annual interest on the cost of deep-water extensions will pay for the necessary dredging five times over.

The improvement of tidal flats for commercial purposes is looming up everywhere. When the fact is considered that the new property, after full improvement, can be readily sold for $30 000 per acre, one can see how easy it is to pay for proposed schemes.

Everywhere in Europe it is customary for the government to condemn and purchase all property contiguous to a proposed harbor work, and, after improvements are completed, sell the property to the highest bidder. As a result, it not only gets all its money back, but in addition a handsome profit. The writer fails to see why the same cannot be done in the United States.

The work for bar dredges is growing more important every day. Where the entrance is largely under good shelter, the work can be done for 4 or 5 cents per cu. yd.; but where the bar is exposed to heavy deep-sea swells a large part of the time, the working period is cut down fully one-half, and the cost naturally goes up to 8 and 10 cents per cu. yd. These results are so flattering that harbors of any importance cannot afford to get along without a good bar dredge for general use, as it will pay back its first costs in one year's operation.

E. P. Goodrich, M. Am. Soc. C. E.—Having been a student of port problems for some years, and being intimately connected with some of the work described in this paper, the speaker has studied it with considerable attention. Concerning several points, his interest has been specially aroused. The general problem of the Panama Canal and its effect on the commerce of the world is of great interest, and, together with the various physical problems discussed by the authors, has been of professional interest to the speaker. On these matters, however, he does not care to make any comments. Mr. Goodrich.

Concerning several non-professional points, the speaker's interest

Mr. Goodrich.

has been similarly aroused. Among these is the fact that, in a professional paper before the American Society of Civil Engineers, nothing but an obviously exaggerated newspaper report has been used in describing the port conditions at Los Angeles, Cal. The speaker may lay himself open to criticism for possessing unprofessional curiosity, but he must confess that had it been possible, he would have liked to await the authors' final discussion in order to ascertain whether or not they would correct the descriptions of the projected Los Angeles work, by making use of modified but obviously more accurate subsequent newspaper articles, to the files of which they evidently have access. The speaker is in entire accord with the opinion expressed in the paper, that it is possible that the popular enthusiasm which is now working such wonders on the Pacific slope may go too far, and that the pendulum may eventually start on a reverse swing. Thus, both in Portland, Ore., and in Los Angeles, Cal., he has laid himself open to the possibility of becoming unpopular by sounding a strong note of conservatism. It may not be out of place to state that the newspapers in both cities reported such fact, which might have been discovered by the authors had they read the local papers carefully. Because of the juxtaposition of the speaker's name, coupled with certain comments about the Los Angeles work, with the authors' reference to "shrewd promoters of port development and no less shrewd port engineering experts," who "will doubtless make the most of the present opportunity and ride on the crest of the flood wave to a point which the normal depth of water would not permit them to reach," he is afraid that casual readers will obtain an erroneous conception of the Los Angeles work and of his connection with it. Even the qualifications inserted by the authors are considered inadequate to meet the exactions of truth, and, therefore, the following facts are presented to the Society in an effort to secure justice for a city which the authors themselves have characterized as "incontestably the center of activity of Southern California" and destined to "become a great port, not because Nature made it so, but because her own virile people have said so."

The facts (which might have been ascertained by correspondence or by perusal of public prints) are as follows: The City of Los Angeles owns about 200 acres in the outer harbor, comprised in two tracts of about 150 and 50 acres, respectively. The outer harbor works now contemplate the immediate improvement of only one of these tracts, work on the 50-acre tract being practically under contract to the extent of bulkheading and filling, while plans for the 150-acre tract are in process of evolution, the detailed design being made subject to the determination of certain physical conditions with regard to currents, the occurrence of rock in the foundations, and the securing of certain real estate to provide rights of way for means of access.

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In a professional paper* published nearly a year ago by Amos A. Fries, M. Am. Soc. C. E., Captain, Corps of Engineers, U. S. A., a suggestion was made with regard to the possibility of further improvement of the outer harbor, proposing a tremendous breakwater and certain long piers similar to those described by the authors and ascribed to the speaker:

"* * * due to the fact that the ocean bottom becomes flatter as you go east from Point Fermin, the breakwater can be extended to inclose any amount of anchorage that may be desired. Indeed, a 25 000-foot extension, should that much ever be required, could be made on almost the same line as the outer arm of the present breakwater, and while keeping in depths averaging barely 48 feet would inclose 10 square miles of water, half of which would average more than 36 feet.

* * * * * *

"Not only can the breakwater be greatly extended, but if fifty or one hundred years hence a long extension becomes necessary, the harbor frontage itself can be increased at least 17 miles by the construction of nine slips between Deadmans Island and the entrance to the Long Beach Harbor. The slips beginning at the present 18-foot curve could be made in lengths varying from 6 500 to 2 100 feet, with a tongue of land 1 000 feet in width between each two slips.

"It would seem advisable, whenever any considerable extension of a breakwater is made, to leave a gap 2 000 feet in width between the present breakwater and the beginning of the extension."

While the authors state that great reliance is being placed on the inner harbor in the development of port facilities, they also say that:

"A great saving fact in the enormous labor of building the Harbor of Los Angeles is its close relation to the industrial development of the city. The lands into which the waterways are being dredged are admirably adapted for factory locations, and the material of excavation is being used in making the necessary fills. The whole development goes hand in hand in a way to produce the best results."

It is the speaker's firm opinion that the inner harbor will be developed almost exclusively for industrial plants and the outer harbor for deep-sea tonnage. At the wharves of the inner harbor, vessels with full cargoes for special manufacturing plants will berth. In order to make the best use of certain dredging which has already been completed, the speaker recommended, and it is understood that the contracts have now been let for, certain temporary wharves located on one of the arms of the inner harbor as now laid out. Only a portion of this wharf will be shedded, and this whole improvement will be carefully studied in an effort to determine what is likely to be the future of that portion of the port. It is further believed that the authors should have put their qualification with regard to the profitableness of reclaiming tide flats, noted under the head of "Dredging,"

* "Los Angeles Harbor," *Professional Memoirs*, Corps of Engineers, U. S. A., and Engineer Department at Large, Vol. IV, No. 13 (Jan.-Feb., 1912), p. 1.

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in closer proximity to the point they endeavor to make of the great cost of doing the harbor work in Los Angeles. They say:

"Now that the reclamation of tide flats is becoming so profitable an enterprise, dredging will be resorted to more than ever, the operation serving the double purpose of excavating slips and channels and filling the abutting lands."

Increased real estate values will be much greater in Los Angeles in comparison than in many other locations, so that moneys expended will produce larger returns for self-supporting enterprises, such as harbor propositions have generally shown themselves to be, and the criticism of the costly nature of the work at Los Angeles Harbor submitted by the authors becomes largely nullified. In reference to this, it may be well to call further attention to what the authors say with regard to San Francisco Bay:

"The shoaling of San Francisco Bay is one of those great natural blessings which the unthinking are so accustomed to look on as a curse. One-tenth of its natural area, with deep connecting channels, would serve every possible need of commerce, while the other nine-tenths would be of immeasurably greater benefit reclaimed and turned to industrial or agricultural use. Every cubic yard of earth washed down from the rugged slopes of the mountains is worth a thousand times more in those low areas, where it is turned to efficient use in the service of Man."

As to the inner harbor at Los Angeles, the speaker has recommended certain alterations in the harbor lines, a portion of which proposed changes has been presented to the War Department for consideration, and it is hoped will receive its approval. Again, with regard to the inner harbor, such changes in harbor lines are in close accord with the recommendations contained in the paper by Capt. Fries, who writes as follows:

"Between Deadmans Island and the turning basin in the inner harbor there are 18 000 feet of bulkhead lines and 500 acres of land, most of which is now reclaimed. The frontage there may be increased a few thousand feet by slips. Above the turning basin, in the east and west basins combined, there are 750 acres of reclaimed land and 52 000 feet of frontage exclusive of the Salt Lake Railroad Company's land on the south and east. This frontage may be increased economically by slips to the extent of 13 000 feet.

"The above is along present approved harbor lines, and while the total—including the slips suggested by the writer and the 12 000 feet along the Salt Lake Railroad Company's property—amounts to 132 000 feet, or 25 miles, it does not represent half the frontage that can be developed if the future shall show that more is needed.

"Bounded by the bluffs of San Pedro on the west, the Anaheim Road and the city of Wilmington on the north, the City of Long Beach on the east, and San Pedro Bay on the south, there are some 8 square miles (about 5 000 acres) of swamp, tide, and submerged

lands capable of being practically improved as part of the inner harbor. Before this is all developed it is evident that the present anchorage area will be too small. Mr. Goodrich.

* * * * * *

"* * * the land owned by the Salt Lake Railroad Company between the Long Beach Harbor and the east basin can probably best be developed by slips opening into the east basin and the Cerritos Channel between it and the Long Beach Harbor, giving a frontage of 12½ miles. On Plate V the channels are shown 500 feet wide on the north side of Cerritos Channel, where they are about 1 mile in length, and 300 feet wide on the south side where the lengths are 2 000 feet."

The authors are entirely wrong with regard to their criticism of the possibilities of the inner harbor of Los Angeles becoming silted by material carried in the floods of the Los Angeles and San Gabriel Rivers. The speaker cannot do better than quote again from the report of Capt. Fries:

"The question of maintenance of depths is always a very important one when considering the future of a harbor. In this matter Los Angeles Harbor is exceedingly fortunate. Indeed, it is hard to conceive of an ocean harbor that will cost less to maintain. The two causes of the deterioration of a harbor are silt carried down by rivers flowing into the harbor and sand piled up at the entrance by cross-currents and wave action.

"Ordinarily, the Los Angeles River is the only one whose waters reach the harbor during the rainy season. During the greater part of the year the river goes entirely dry before reaching the sea, due to irrigation and the great quantities of water used in the city of Los Angeles. It is noted, however, that during the winter of 1910-1911 the San Gabriel River, which ordinarily flows into Alamitos Bay, about 10 miles east of Los Angeles Harbor, broke from its regular channel into one known as New River at a point about 20 miles from the harbor and, following the New River, united with the Los Angeles River at a point about 5 miles north of the harbor. This was one of the worst floods known in many years and carried into the Los Angeles Harbor possibly 350 000 cubic yards of material. Efforts are now being made by railroad companies and agricultural interests in the vicinity of the break to make such improvements in the bank of the river as will confine it in the future to its regular channel, emptying into Alamitos Bay.

"The Government has been asked to aid in this as a measure of protection to the harbor, and steps are being taken in that direction. Unquestionably this improvement will be made, but even if the San Gabriel River should regularly flow into the Los Angeles Harbor, the cost for dredging would still be comparatively small, as the records for nearly fifty years show only five serious floods. These occurred in 1867, 1873, 1884, 1891, and 1911. The Los Angeles River itself carries down some material in smaller floods at lesser intervals, but the amount is so small as to be scarcely noticeable, except just where the river first enters the deep water of the harbor."

Mr. Goodrich. Another point described by Capt. Fries, and now being actively pushed by the local authorities, is the widening of the channel between the inner and outer harbors to a minimum of 750 ft. A request for this improvement has been formally filed with the War Department, and it is believed that the Washington authorities look favorably on the suggestion.

In discussing the administrative systems of the ports, the authors criticize the conditions in Los Angeles, where there was originally and is now technically a divided responsibility. The trouble described by them, however, has been entirely overcome by the Mayor, who appointed what is called an "Advisory Harbor Commission," consisting of the two boards meeting jointly, with the Mayor as Chairman. During the meetings of this joint board all matters relating to harbor affairs are talked out, and differences of opinion are eliminated. The Mayor's solution of the small difficulty described by the authors has proven highly advantageous to the community.

With reference to the table of comparative costs to ship and to cargo in Pacific Coast ports, the fact should be pointed out that, with the exception of San Francisco, the table shows Los Angeles to have the lowest total cost. It should be noted further that the handling rate of 41.8 cents has been taken from an average which might be vastly different in an actual case. The dropping of the 0.8 cent would reduce the cost by nearly $200.

The speaker is extremely sorry that the authors were not more accurate in their statements with regard to Los Angeles Harbor, and believes that it throws grave doubt on the accuracy of the paper in other points.

Mr. Haupt. Lewis M. Haupt, M. Am. Soc. C. E. (by letter).—This is a very comprehensive paper, not only on the engineering problems of Pacific Coast harbors, but also on their commercial relations; and, in view of interesting discussions previously published in the *Transactions* of this Society,* the present contribution is one of great value to the Profession as a guide to and aid in the early solution of these intricate questions.

History and experience are the foundations of theory on which the engineer must rely to shape his course in order that he may best serve his Profession and his country by removing these obstacles to international commerce, hence it is that this paper is peculiarly appropriate on the eve of the completion of the Panama Canal. As it

* "On the Straits of Juan de Fuca, Puget Sound; and Government Improvements on the Pacific Coast," by B. W. De Courcy, M. Am. Soc. C. E., Vol. XXV, p. 420.
"Improving the Entrance to a Bar Harbor by a Single Jetty," by T. W. Symons, M. Am. Soc. C. E., Vol. XXXVI, p. 109.
"Description of Coos Bay, Oregon, and the Improvement of Its Entrance by the Government," by William W. Harts, M. Am. Soc. C. E., Vol. XLVI, p. 482.
"Seacoast Harbors in the United States," by C. E. Gillette, M. Am. Soc. C. E., Vol. LIV, Part A, pp. 297, 385.
"Notes on the Bar Harbors at the Entrances to Coos Bay and Umpqua and Siuslaw Rivers, Oregon," by Morton L. Tower, M. Am. Soc. C. E., Vol. LXXI, p. 349.

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covers all the important ports from San Diego to Vancouver, no detailed discussion is possible, nor are the maps appended sufficient for such purpose; the text, however, supplements them in large part by stating local conditions and results, and several extracts therefrom are submitted as pointing to such modifications of practice and policy as to give promise of much greater certainty of securing early results.

As it is not possible to review all the cases cited, that of the typical and important Columbia Bar is taken as an example, because, as the authors very justly state:

"This work * * * is probably the largest and most difficult of its kind ever attempted * * *. The two great obstacles to be overcome * * * are the storms and the teredo * * *. The roughness of the sea precludes the use of barges for dumping rock, thus necessitating a trestle, and the trestle piling is the particular delight of the teredo, which puts it out of commission in from 10 to 20 months. * * * the embankment is progressively shaken down during each winter season."

Specifically, the work is described as follows:

"The jetty was to be built of large size stone on a brush mattress and raised to the level of low tide. Later, the project was changed to raise it to high tide, and four groins were to be built from the north side to arrest scour. Work was begun in 1885 * * *, and was completed ten years later at half the estimate. The depth over the bar had increased, in the meanwhile, from 21 to 31 ft., and the work seemed to have accomplished its purpose perfectly.

* * * * * *

"Several years later there was only the original depth of 21 ft. * * *. A new project was adopted, extending the jetty 3 miles farther, * * * to be supplemented by dredging over the bar. * * * a permanent depth of 30 ft. is sought.

"The jetty itself, as now being built, consists of a bed course of small rock as a substitute for brush mattress, it being found impracticable to use the mattress beyond the shoal depths, * * * and the whole is covered on the seaward slope with very heavy rock ranging in weight from 6 to 16 tons per piece."

These extracts indicate that the usual resources of jetties built out from the shore by the aid of trestles and laid on mattresses, supplemented by dredging, are at least very unsatisfactory, if not impractical, at this locality, because of the activity of the teredo and the waves, so that the method has been modified to conform more closely to that proposed in the recent paper* by H. C. Ripley, M. Am. Soc. C. E.

Notwithstanding the great skill and ingenuity expended in the construction and maintenance of this trestle, more than 6 miles in length, and the excellent system of operation, the physical conditions are such as to retard its advance to such an extent that it seems

* "How to Build a Stone Jetty on a Sand Bottom in the Open Sea," *Transactions*, Am. Soc. C. E., Vol. LXXV, p. 1040.

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impossible to overtake the deposits of littoral drift which constitute the bar; for the last official report available at this writing, states the following facts: The estimated cost to secure a depth of 40 ft. was $3 715 000. This project was revised to raise the jetty to mid-tide level, in 1909, at a cost of $3 529 300, and to make it 25 ft. wide at that level. In some places it is in 39-ft. depths, thus requiring an enormous increase in the amount of rock. Between September 20th, 1910, and June 30th, 1911, the dredge worked on the bar 62 days, removing 212 080 cu. yd. The project is 85% completed.

"The survey of June shows the channel to have shifted about 2 500 ft. to the northwest, and the depths vary from 25 to 27½ ft., an increase of 1 ft. over last year.

"The life of the trestle is very uncertain. * * * It is believed that the contraction of the entrance by the north jetty may be followed by scouring along the north side of the south jetty (2 miles distant), and that for its maintenance two more groins should be provided, each about 500 ft. long. The total appropriations since 1902 aggregate $7 901 852.25. The outer 24-ft. contour has advanced some 3 000 ft. since 1902, and the outer depths of 50 ft. in that year had shoaled to 24 ft. by 1909. On the southerly side of the jetty the 24-ft. curve had advanced about 4 000 ft. within 2 years, or about twice the length of the jetty extension in the same time, and large deposits had been made in the throat of the entrance between the jetty and Peacock Spit."

The deductions from these statements are that the extension of the jetty has caused deep erosion at its outer end, requiring enormous quantities of rock to fill voids formerly occupied by sand in place; the rapid advance of the outer slope, accompanied by a shoaling of 26 ft. at the 4-fathom contour; the inability to overtake this advance by the jetty; the shifting of the channel some ½ mile to the northwest by the deposits of drift; the great excess of cost, amounting to more than $1 000 000 per ft. of depth gained; and the proposal to erect the second jetty extending out from Cape Disappointment for a distance of 2 miles, and at this same distance from the present jetty, but neither of them reaching to the crest of the bar by nearly a mile. The result of this must be to aggravate the seaward movement of the bar, while affording little or no protection for dredging.

It is also apparent that the report of 85% completion does not apply to the north jetty, nor to the ultimate extension of both, if this method is to be the main reliance for the improvement of this bar. The purpose of the south jetty, slightly convex to the channel, 4¼ miles in length, was to extend the protecting spit to a point abreast of Cape Disappointment and thus secure the co-operation of that headland, as a second jetty. This has resulted in disappointment, and any extensions of two jetties, it would seem, would give no promise of any different result, because there is no change in the general regimen

of the entrance, affecting the relative equilibrium of the flood and ebb currents. Mr. Haupt.

If the life of the piling, due to the teredo, is taken at the maximum limit of 20 months, then the entire structure subject to their attacks, must be rebuilt in that brief time, necessitating constant repairs and heavy expenses for maintenance. Moreover, the statement from actual experience that the dredge was able to work 62 days out of 283, or 22% of the time, covering the winter season, would give a reasonable assurance that it may be quite possible to work on the bar by creating an insular barrier on its outer slope, as a nucleus, sufficient to serve as a breakwater to protect a floating plant. From this a rock jetty could be extended shoreward to connect the deep-water areas on its outer and inner slopes, and to protect the crest from the littoral drift, as well as create a reaction from the impingement of the ample discharge on its concave face which would cut a channel more than 40 ft. deep automatically, as is shown by the existing channel at the base of the Point Ellice headland just within the throat of the entrance, which channel is about 8 miles long and more than 40 ft. deep, having a radius of 5 miles.

So confident is the writer that such a permanent, navigable channel could be readily obtained that, on June 9th, 1902, at the instance of the Senator from Oregon, he filed with the Secretary of War a proposal to guarantee such a channel for the sum of $2 500 000, which proposal was referred to a Special Board of Engineers for consideration and report. On October 14th, the Board gave a hearing to the officials of the Reaction Jetty Company (organized with a capital of $1 000 000 to execute the work), at which time a full discussion was submitted to the Board, all the members being present. On November 10th, 1902, the Board requested further information, and submitted twenty-three queries which were categorically answered on the 17th, and after several months of consideration, the report was filed with the Secretary of War, but its contents were not disclosed, and the Reaction Jetty Company was advised that it could ascertain the findings when the annual report of the Chief of Engineers was published. As that report has expunged all reference to the special provisions of the tender then submitted, and as 10 years have elapsed since it was made, and the recommendations of the Board, which were estimated to cost $2 260 000 for the extensions of the south jetty, at mid-tide level, a distance of 2½ miles, have been executed and for which appropriations approximating $8 000 000 have been set aside, it would seem appropriate that the terms of that proposal should be reviewed, as a matter of interest to the parties concerned, merely as an index to the early solution of this difficult but important problem of securing an open channel of ample capacity at reasonable cost without bar advance.

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The principles involved have been tested on a practical scale at a condemned inlet on the Texas Coast, and notwithstanding the most serious physical as well as "metaphysical" obstacles, a detached jetty actually secured the full predicted depth of 20 ft. before the work was connected with the shores. Then it was seriously impaired, and the channel shoaled to 9 ft., requiring several years before equilibrium was restored. Thus assurance becomes doubly sure.

Briefly, the reaction jetty proposal reviewed the physical condition of the bar and its changes, as shown from official charts, stating that to obtain the 40-ft. channel would require the removal of some 30 000 000 cu. yd. which would be impracticable by dredging in the open sea with no protection works, as it would require some 30 years, if there were no littoral drift to maintain the supply, and would cost more than $6 000 000.

To control this drift and create an automatic channel, the company designed a permanent structure to create a zone of local activity across the bar, to arrest the drift on its convex face, being on the windward or "weather" side of the proposed crossing, and, at the same time, to cause a continuous reaction, with erosion and deepening on its concave face, by utilizing the forces and agencies of impact, head, reaction, concentration, gravity, and continuous deflection, whereby a sufficient amount of the potential energy of the affluent water is developed locally to produce deep scour and lateral transportation.

The old jetty, completed in 1895, which created the temporary 30-ft. depth, had caused the bar to shoal up at the rate of 3 500 000 cu. yd. per annum, and pushed it seaward about 1 mile, reducing depths of 60 ft. to 30 ft., and less.

To avoid this advance, the company proposed to make its work discontinuous, leaving a gap of about 2 miles between the outer end of the existing jetty and the inner end of the breakwater. The company also proposed to reverse the direction of the curvature of the breakwater, so as to place its cutting face toward the ebb currents and to receive them at first tangentially and, by gradual but continuous deflections, cause a constantly increasing pressure on the most vital part of the ebb for a distance of about 2 miles across the bar. Thus, too, the ingress of the flood tide would not be impaired, and the conditions of equilibrium would be changed in favor of the ebb stream.

Numerous other advantages, not incidental to straight jetties, were pointed out, time and expense were to be saved, and no risk was to be incurred by the Government, which was to be fully safeguarded by bonds, and pay only for work in place and depths secured.

Plans and cross-sections of the existing and proposed channels were submitted, with the form and dimensions of the proposed structure, closing with these words:

"As the proposed plan is novel and the location one of exceptional difficulty, this Company desires, if permitted, to accept all the responsibility for the success or failure of its plan, and will furnish such security as the Secretary of War may require to protect the United States from loss by reason of its failure. It will also satisfy the Secretary of its ability to carry out the contract to execute these plans as rapidly as the physical conditions will permit * * *. We believe that this proposition will be found to be 'the most economical and advantageous to the Government,'* since it is based upon the utilization of a part of the enormous energy now going to waste over the bar." Mr. Haupt.

After summing up the special advantage to be secured by the acceptance of the proposal, the Company pledged its good faith for its execution in the following words:

"If this Board, therefore, can see its way to recommend to the War Department the acceptance of this proposition for the relief of the Columbia River Basin, it is believed that it will perform a public service of great value to the country, and the Company will accept the trust and the responsibility of its execution in good faith, and will release the Government from any or all claims for royalties incidental to the use of its patents at this place."

The sequel to this, and similar tenders with like guaranties, indicated so plainly that the policy of past administrations was not to encourage the letting of contracts to extrinsic parties, however guaranteed, that the Reaction Jetty Company was dissolved.

The changes on the bar during the past 10 years have served to confirm the predictions made to the Board of 1902 as to the probable effects of the Government plan, and the elaborate report submitted at that time only alluded to the offer of the Company in a single paragraph as follows:†

"The Board knows of no plan for the improvement of this entrance that has not contemplated one or two jetties extending continuously seaward from the points of the entrance that are fixed in position naturally or artificially. The turbulence of the bar is such that operations from floating plant have never been seriously considered as practicable, and any work must be executed from a structure built out from the shore. Even the structure proposed by the Reaction Jetty Company, while nominally a detached breakwater, is in effect an extension of the old jetty, * * *."

This was the only reference, and the extension of the south jetty, as since constructed, was recommended, notwithstanding the following statements in the report:

"The Board cannot expect that an advance of the bar at this point will not follow the construction of the jetties and the removal of the large quantity of sand necessary to secure a 40-ft. channel. Such advances have invariably been found in all jetty harbors."

* Terms of the law authorizing the Secretary to make such contracts.

† Report, Chief of Engineers, U. S. A., 1902, p. 2305.

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But it is expected that:

"The waves and strong littoral currents have at this point their maximum effect, in retarding and counteracting the bar advance, and, unless the history of the past 60 years is misleading, that advance will be speedily checked and probably reversed with a return of the outer bar slope toward its present location."

These hopes do not appear to have been justified by the results in the later reports, and the question arises as to whether or not there may ever be a better solution than the two-jetty plan, which, it is conceded, "invariably" advances the bars in "all" cases. The answer may be suggested by the experience at Aransas Pass during the operation of the partial reaction breakwater, which not only prevented bar advance but caused a recession of the outer contours until the channel was cut entirely through, without injury to the structure, by a feeble diurnal tide. There are many other elements in this report of the Board of 1902-03 which are worthy of consideration, but space and time prevent the writer from mentioning them.

It is hoped that these suggestions may open the door to a broader consideration of the policies and possibilities of this nation for removing physical obstacles to international trade, and be of greater economic advantage to all people.

Some light is thrown on the status of the two-jetty system of surmounting ocean bars by the following extracts from a letter by Col. E. H. Ropes, a layman of New York, who was endeavoring to effect an entrance from the Gulf of Mexico to the bluffs across Corpus Christi Bay, Texas, addressed to Mr. Brewster Cameron, also a layman, interested in promoting the opening of the near-by entrance at Aransas Pass where three previous efforts had failed.*

As this letter expresses the opinion of one who had given his time and means to a project on which he was willing to stake his fortune, after careful investigation, it has a direct bearing on the subject as a practical demonstration of the futility of undertaking a maritime work without consideration of all the elements affecting the problem.

*"The Plea for 'Ropes' Pass.'*

"NEW YORK CITY, May 24th, 1894.

"MR. BREWSTER CAMERON,
"Baltimore, Md.

"DEAR SIR:— * * * If you are in a position to go ahead with Aransas Pass, I have no proposition to make. If you are not, or if you had considered the outcome of your efforts there so dubious as to incline you to consider a proposition from me I should make one.

* This letter is a part of the posthumous correspondence left by Mr. Cameron who lost his life by slipping into the Niagara Rapids above the Falls after he had successfully reorganized the Aransas Pass Harbor Company and inaugurated the work on the plans of the reaction jetty which secured the requisite depths before the second jetty was built.

The whole thing turns upon the condition of your prospects for Aransas. Mr. Haupt.

"You are right in thinking I will be benefited by deep water at Aransas. It will be far more to me than the public supposes. I have, therefore, the best of reasons for wishing you success. * * *

"The objections you cite to Ropes' Pass are based upon wholly erroneous ideas concerning the scientific project. the commercial plan, and the financial methods. Of this I could satisfy you in a brief interview.

"1. The channel across Mustang Island, no where goes through land 30 feet high. Half the distance is through flats covered at high tide; the rest has an average height of 3 to 10 feet, * * * while a vast amount of dredging will be required at Aransas for dockage in any depth exceeding 12 feet. At Ropes' Pass the dredging for channel makes the dockage, and by reason of the shorter passage and greater depths the currents will be immensely more powerful to scour, thus saving much excavation.

"2. The dockage, being on both sides of the channel, is now completely land-locked. No harbor could be more so.

"3. We can also make it a free port * * * while Aransas will doubtless charge tolls.

"4. But the jetty work is the big item, as has been shown at every Texas point. Dredging in smooth water is child's play in comparison. Do you know that more than $9 000 000 has been spent on Texas jetties, and with no important permanent results? Ropes' Pass requires less jetty work than any proposed harbor on that coast.

"5. * * * I know more now than I did five years ago about Texas sand-bars. The official reports show that every prophecy concerning the results of work on each of the Texas bars has been negatived by experience. Latterly the Reviewing Boards have been denouncing such predictions as the product of 'ignorance' and as attempts to impose upon 'the credulity of mankind'! Engineers of the highest rank declare that no prediction can possibly be made of the effect of operations on those bars. All the strong language occurs in the official reports. Galveston was the immediate theme, but the principles apply equally well to all the Texas bars. The facts sicken me of all bar work on that coast. Why, they have been at work 24 years at Galveston, and at other points nearly as long. You know the results. Every bar, as soon as it is touched, commences to move seaward. That is the real trouble at the Brazos. The existing jetties end where deep water was when they were begun. The bar has been racing with the jetties, just as at Galveston.

"6. Ropes' Pass has great advantage over others in length of jetties, in size, depth, and nearness of internal basin, and in other important matters, but none counts as much as the fact that we have no bar to deal with. It is a steady slope all the way from beach to 90-ft. depth. We can figure exactly how much rock will be required to build our jetties to any given depth. No living man can do this at any other point.

"If the bars had only stood still at Galveston and Brazos, the jetties would now stand in deep water. Not only this, but no bar can form at Ropes' Pass until the whole shape of the coast has changed, because

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our jetties will shut away the bar building forces from the channel, and it will take hundreds of years for the whole island to build out to these ends.

"Your impression that the conditions are 'more favorable' at Aransas than at Ropes' is natural, but erroneous."

(The remainder of the communication refers to financing the project, and asks for a conference.)

The sequel is well known, for the effort to dredge a cut across Mustang Island into Corpus Christi Bay merely made an indent in the beach, destroying the continuity of the littoral drift, which was driven into this artificial bight, and closed up the channel in the wake of the dredge which was imprisoned in its own grave. Had the leeward jetty been built, in advance, to a sufficient distance to intercept the drift, there might have been a fair chance of opening the cut through to the bay, and, with proper work, of maintaining it.

This work, therefore, was abandoned, while that at Aransas Pass, due to the new order of construction by building in from the outer end by a floating plant and on a concave trace, has automatically scoured out its own channel, more than 20 ft. in depth and 300 ft. in width, without bar advance, at a cost to the Government of less than one-fourth of its original estimate, and with a 14-in. diurnal tide. It is true that subsequently a second straight jetty was built, at a cost, including other superfluous works, of more than $1 000 000, but the immediate effect of connecting the "Haupt breakwater" with the shore of St. Joseph's Island was to shoal the 20-ft. channel to about 9 ft. and reduce the tidal energy to such an extent that nearly 4 years elapsed before the former 20-ft. channel was recovered. This experience, therefore, furnishes an excellent practical example of the removal of an ocean bar by a portion of a single barrier placed across its crest, without aid from dredging and without bar advance, at a very great economy in cost, and should commend itself to the Profession as worthy of acceptation in many other cases, notably at the mouth of the Columbia River, Grays Harbor, Coos Bay, etc., on the Pacific Coast, where the conditions are exceptionally favorable.

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H. M. CHITTENDEN, M. AM. SOC. C. E. (by letter).—Mr. Goodrich has permitted an unnecessary sensitiveness to the writer's rather jocular commentary on his ambitious vision of the future port of Los Angeles to give a false color to his estimate of what the writer said about that port. A careful perusal of the treatment of that subject, mainly in Section II of the paper, will show it to be substantially accurate, though lacking in detail, as was necessarily the case. Particularly inexcusable is the following remark by Mr. Goodrich: "Nothing but an obviously exaggerated newspaper report has been used in describing the port conditions at Los Angeles." The most superficial examination of the paper would show the absurdity of that

statement. As a matter of fact, all available literature, including Major Fries' admirable report, was used, and this was supplemented by a long list of questions sent to an official of the Port of Los Angeles asking for data on all phases of the question. Gen. Chittenden.

As to the newspaper report, which is what really annoys Mr. Goodrich, it came to hand just before the paper was finished. It fitted in so perfectly with the writer's treatment of "plans for the future" and seemed to be so much in detail and to bear so unmistakably Mr. Goodrich's authority, that the writer ventured, with some misgiving, it is true, to make use of it. If it committed him to any erroneous suggestions as to the future of Los Angeles which later data would have modified, he is, of course, only too glad to accept corrections.

The writer will not comment on Mr. Goodrich's references to estimates of cost of Los Angeles work, nor to administrative control, for they are so manifestly unjust that Mr. Goodrich must himself realize the fact if he will but compare his criticism with what the writer really said.

The comment on the writer's parenthetical reference to the Los Angeles and San Gabriel Rivers is a case of assuming that something was meant which was not said, and then criticising that something. The writer's description of the natural state of those streams is literally correct; but he did not anywhere say, or even imply, that these streams were a menace to the integrity of the harbor. The writer has carefully looked over his paper to see if it contains any hint of danger "of the inner harbor of Los Angeles becoming silted up by material carried in the floods" of these streams, and he can find none. All this, and the careful refutation of it, are purely the result of Mr. Goodrich's imagining what the writer did not say.

In short, Mr. Goodrich has permitted himself, most mistakenly, to class the writer as a "knocker" of the Port of Los Angeles. Yet a perusal of the paper will show it to be, not only wholly sympathetic in tone, but full of admiration for the wonderful work which the people of Los Angeles are doing.

The impartial reader of the paper cannot fail to observe that it endeavors to draw a just comparison among the leading ports of the coast as to their respective advantages and drawbacks. The partisans of each will naturally take exception as to their particular port, magnifying the advantages and minimizing the drawbacks; but, when all is said and done, the case for the principal United States ports on the Pacific Coast will stand substantially as summarized below:

*San Diego.*—Advantages: A magnificent natural harbor which, with a moderate degree of development, would accommodate the shipping of the world.

Drawbacks: A sharp restriction of hinterland (tributary commer-

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cial territory) by the national frontier immediately to the south and a mountain range on the east. The first natural outlet to the eastward is in the vicinity of Los Angeles.

*Los Angeles.*—Advantages: Commercially located where the great southern transcontinental routes, and also one from the interior, debouch from the mountains to the coast plain; strategic location for ocean terminal; extensive and productive near-by hinterland; good connection with the hinterland farther back; climate an asset of enormous value in development of country.

Drawbacks: Entire absence of an adequate natural port, and consequent necessity of creating one almost wholly by artificial means; cost of port development greatly enhanced by this fact.

*San Francisco Bay.*—Advantages: A perfect natural harbor of great magnitude, close to the sea; a hinterland which embraces the heart of California's agricultural and mineral producing regions—one of the richest in the world; on the line of the great routes north and south; in direct rail connection with all the region to the eastward; a commerce and development half a century old, with the immense force of customs and established lines of trade in its favor; most centrally located of all the ports for the commerce of the Pacific; important naval and military bases.

*Portland.*—Advantages: Unexcelled strategic location at great crossroads of north and south, and east and west routes; a productive local hinterland (agricultural) in the Willamette and other near-by valleys; immense timber resources; a water-grade route to the eastward—the only one from the Pacific Coast of the United States; consequently a vast natural interior hinterland.

Drawbacks: Long distance and defective natural channel to sea which discourages entrance of largest vessels—a drawback as yet only partly overcome.

*Puget Sound.*—Advantages: Almost perfect natural harbors, the principal defect being excess of depth; center of great timber producing region; center of great fish producing region; limited local agricultural hinterland; extensive agricultural hinterland back of the mountains; the natural emporium for the Alaska trade; well located for Oriental trade; important naval and military base.

Drawbacks: Walled off from natural hinterland to eastward by an immense range of mountains, the main passes being less than 75 miles from tide-water and more than 3 000 ft. high; crossed, however, by three railways, which give same terminal rates as to Portland.

A most striking illustration of the drawbacks above described of both the Lower Columbia and of Puget Sound was seen in the conditions which prevailed on January 7th and 8th, 1913. A fierce storm was causing wrecks and great loss of life at the mouth of the Columbia, while deep snow, avalanches, and (soon after) floods from melting

snow completely paralyzed rail traffic over the mountains back of Puget Sound, and caused considerable loss of life. Permanently to remove either the handicap of the Columbia Bar or the handicap of the Cascade Mountains will cost an enormous sum, yet both ends must be classed as within the range of practical engineering. Gen. Chittenden

In the foregoing comparative estimate of advantages and drawbacks of Pacific Coast ports it will be noted that San Francisco stands first; and it seems to the writer that she will long continue to stand first, because of her unexcelled advantages. It has also become more and more apparent to him that, unless ports are close competitors in the same field—not distant competitors like Puget Sound and California ports—a mere superiority of port facilities cuts little figure in the matter of competition. Vessels are bound to go where the trade is, even if docks are inferior and charges high, and the writer does not believe that San Francisco or Seattle will take much trade from each other by reason of superior expenditures on docks and wharves; but, with two nearby ports like Seattle and Tacoma, both of which are equally well located, as far as local trade is concerned, and between which the vessel owner sees no choice except in the matter of conveniences and charges, a superior equipment in either might be decisive in its favor.

The writer will refer to one other point, that of port administration. Mr. Goodrich says that Los Angeles has corrected the undesirable condition in port administration prevailing at the time this paper was written. That is fortunate, but the writer does not believe that anything approaching an ideal system will ever be worked out as long as port administration is a function of city government and is thereby necessarily involved in city politics and subject to the vicissitudes of changing administration. That this is the view of sagacious observers on the ground is evident from the following extract,* received after the foregoing statement was written:

"Inefficiency and delay, bickering, obstruction, and even deadlocks will unquestionably be the rule rather than the exception so long as the present machinery for harbor development is relied on by the city. The concentration of power, authority and responsibility in one board, under which the legal, engineering and administrative departments would be placed, will probably have to come before much satisfactory progress is made on this all-important municipal project—the development of Los Angeles harbor."

In a most instructive pamphlet recently issued by the Commonwealth Club of California, Professor C. T. Wright, of the University of California, made some pertinent observations on port administration. The following are some of his conclusions:

"The organization of the harbor governing body should be simple and efficient. Its members should be few in number, with a tenure of

* From the *Los Angeles Tribune*, January 17th, 1913.

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office sufficiently long to permit of the formation and inauguration of a consistent policy.

"The appointment of a full new board almost always results in an entirely new policy. A new board usually rejects a great part of the programme outlined by its predecessors, and spends a large part of its time in preparatory work before it begins or pursues any real constructive programme; and this in turn is superseded by the plan of a succeeding board. The harbor governing body, if ideally constituted, would be a perpetual body, a certain proportion of whose members would retire each year. In other words, it ought not to be possible, or at least it ought not regularly to occur, that the entire board should retire at one time, or even that a majority of the board should do so.

"The harbor governing body should have full authority to carry out the work which it exists to do, subject of course to review by the courts or other higher authority. This power of the governing board should extend to all activities which directly concern shipping.

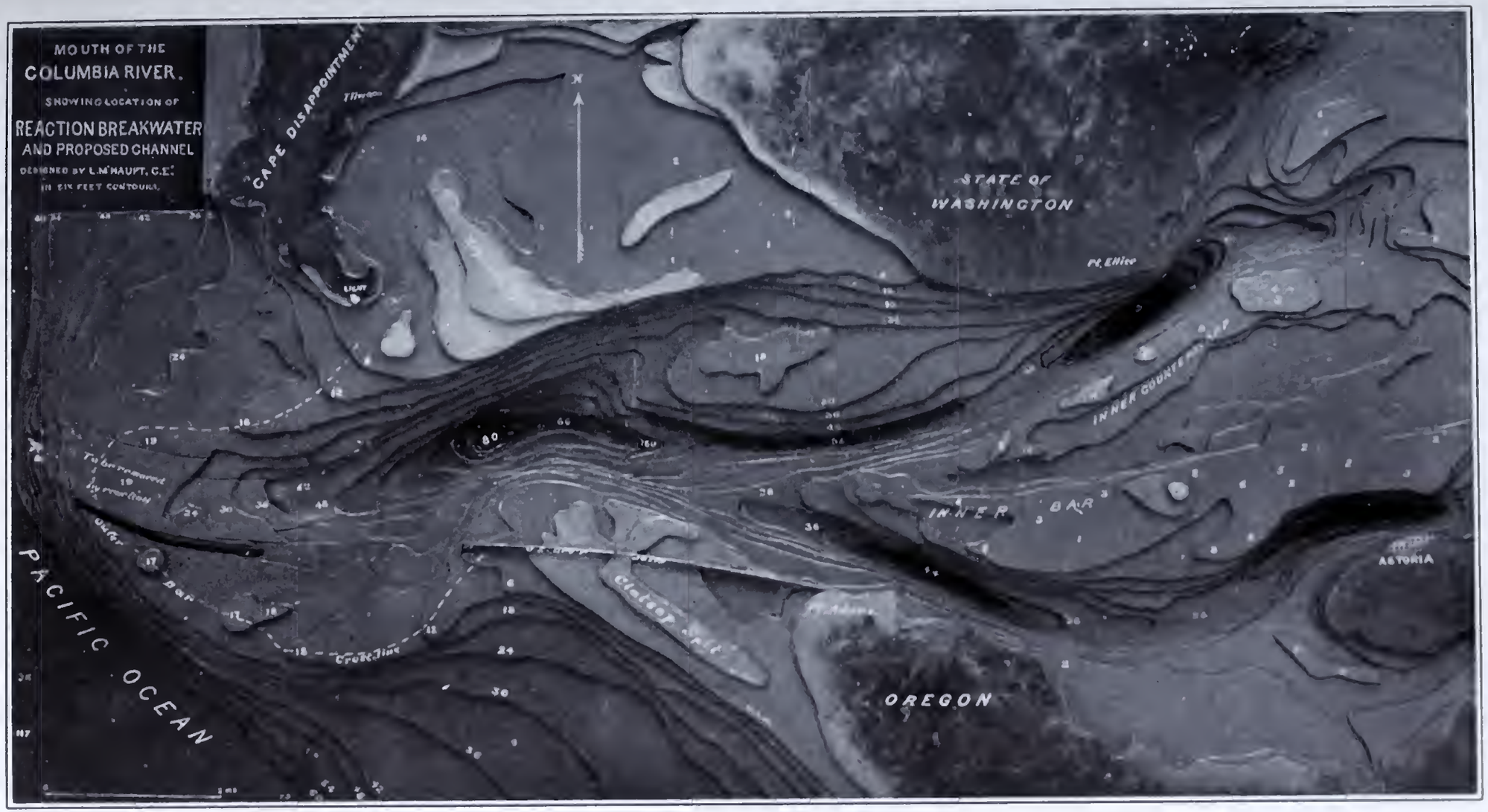
"A harbor governing body should represent a constituency of ample financial ability."

These are sound fundamental principles. While it is perfectly true as a rule that "What'er is best administered is best," and that a very efficient law inefficiently administered may give poor results while a defective law efficiently administered may give good results, still, in the long run, the best law will give the best results. The writer believes that the Washington State statute comes nearer to satisfying the above fundamentals laid down by Professor Wright than any other. The port organization is simple, consisting of three members, entirely free of State, county, or city politics, and responsible directly to the people of the Port District.

The harbor governing body (Port Commission) is a continuing body, the term of office being three years, and only one member being elected each year. No sudden change of policy, with its disturbing features, is possible, as is the case with the San Francisco Board, which is liable to change bodily with every change of State administration.

The powers of the Port Commission are extensive; its activities are directed to the single purpose of port development; it is almost supreme within its restricted sphere, and its authority satisfies perfectly Professor Wright's requirement that it be "both extensive and intensive."

The territorial extent of the constituency and also its financial ability are determined in the original organization of the district. The Port of Seattle, for example, was made co-terminous with King County, in which the City of Seattle is located. "Ample financial ability" does not necessarily mean large financial ability. A small port may have an organization and a financial ability "ample" for itself, which might be quite inadequate for a great port. The system is thoroughly elastic, and is applicable to all conditions, and the writer would commend a study of it by port authorities wherever changes are contemplated in port organizations.




THE MOUTH OF THE COLUMBIA RIVER

SHOWING HOW DEEP, NAVIGABLE CHANNELS ARE MADE AND MAINTAINED BY TIDAL CURRENTS, AS AT POINT ELLICE AND ASTORIA AND HOW THEY MAY BE UTILIZED TO SCOUR A PASSAGE ACROSS THE BAR FOR THE DEEPEST VESSELS, WITH GREAT ECONOMY.

COMPLIMENTS OF

LEWIS M. HAUPT, C. E. PHILADELPHIA, PA.